COMPARATIVE STUDY BETWEEN THE LICHTENSTEIN'S OPEN HERNIOPLASTY & THE MINIMALLY INVASIVE LAPAROSCOPIC HERNIOPLASTY FOR INGUINAL HERNIAS

Dissertation submitted to
The Tamilnadu Dr. M.G.R. Medical University, Chennai
with fulfillment of the regulations for the award of

M.S. Degree in GENERAL SURGERY
BRANCH - I

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CHENNAI - 600 010

May- 2019

CERTIFICATE

This is to certify that this dissertation titled **"A COMPARATIVE STUDY BETWEEN THE LICHTENSTEIN'S OPEN HERNIOPLASTY & THE MINIMALLY INVASIVE LAPAROSCOPIC HERNIOPLASTY FOR INGUINAL HERNIAS"** is the bonafide original work done by **Dr.M.RAJESH MENON,** Post graduate in M.S.General Surgery, during his course in Govt. Kilpauk Medical College and Hospital, Chennai, in partial fulfillment of the regulations of the Tamilnadu Dr.M.G.R. Medical University for the award of **M.S. Degree in General Surgery (Branch I)**.

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DECLARATION

I solemnly declare that this dissertation titled **"A COMPARATIVE STUDY BETWEEN THE LICHTENSTEIN'S OPEN HERNIOPLASTY & THE MINIMALLY INVASIVE LAPAROSCOPIC HERNIOPLASTY FOR INGUINAL HERNIAS",** is an original and genuine Research work carried by me under the guidance of **Prof**.**Dr.R.VASUKI, M.S.,** Department of General Surgery, Govt. Kilpauk Medical College, Chennai - 10.

This dissertation is submitted to **The Tamilnadu Dr.M.G.R. Medical University, Chennai** in partial fulfillment of the University regulations for the award of **Degree of M.S. General Surgery (Branch I)** examinations to be held in May 2019.

Place : Chennai

Date :

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INSTITUTIONAL ETHICS COMMITTEE
GOVT. KILPAUK MEDICAL COLLEGE,
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The Institutional Ethical Committee of Govt. Kilpauk Medical College, Chennai reviewed and discussed the application for approval **"A Comparative study between the Lichenstein's open Hernioplasty versus Minimally Invasive Laparoscopic Hernioplasty for Inguinal Hernias at Govt.Kilpauk Medical College and Hospital "** submitted by Dr.M.RAJESH MENON, M.S Post Graduate, Department of General Surgery, Govt. Kilpauk Medical College, Chennai-10.

The Proposal is **APPROVED.**

The Institutional Ethical Committee expects to be informed about the progress of the study any Adverse Drug Reaction Occurring in the Course of the study any change in the protocol and patient information /informed consent and asks to be provided a copy of the final report.

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INTRODUCTION

INTRODUCTION

"In order to achieve a radical cure of hernia it is absolutely essential to restore those conditions in the area of the hernial orifice, which exist under normal conditions"-Edoardo Bassini.

Annually, more than 20 million groin hernias are repaired worldwide. The general approach for groin hernias is surgical repair regardless the symptoms as there is risk for bowel obstruction and visceral strangulation in untreated cases.

Anterior approach onlay mesh tension free prosthetic repair of the inguinal canal was first demonstrated by Irving Lichtenstein in 1984 which has revolutionized the way hernia repairs have been conducted with very low recurrence levels. **Ralph Ger** was the first in 1982 to report a transabdominal closure of an inguinal hernia defect during a laparoscopy for other reasons. Years later, in 1989, the gynaecologist **S.Bogojavalensky** showed a video demonstrating the laparoscopic intra abdominal incision of the peritoneal hernia sac, subsequently closing the visible muscular defect with a rolled-up piece of polypropylene mesh. Thereafter in 1990 Ger, Shultz, Corbitt, etc. demonstrated laparoscopic hernia repair after conducting a series of trials and studies. Laparoscopic hernia repair is similar to the open preperitoneal approach and can be performed via a transabdominal or totally extra peritoneal route.

As it stands now both anterior open tension free meshplasty and minimally invasive laparoscopic meshplasty techniques are evidence-based and accepted methods with unique advantages and drawbacks for adult hernioplasty.

Lichtenstein's tension free mesh repair has been accepted as a very reliable and uncomplicated way of repairing inguinal hernia with very good results. It is economical, easy to learn/ train and without the need for sophisticated infrastructure. The patients have fewer complications postoperatively with very low recurrence rates compared to tissue repairs done in the past. Hence notwithstanding the perils of having a prosthesis like mesh insitu, it is the most commonly performed and widely accepted technique worldwide today.

On the other hand laparoscopic approach offers many advantages like lesser postoperative pain, analgesic requirements and early return to functional status/ productivity with lesser incidence of chronic debilitating pain than with open mesh repair. It offers the feasibility of examining both sides simultaneously in posterior approach and allow access without disturbing the previous scar tissue in recurrent hernias. However introduction of laparoscopic hernia repair has presented new set of challenges. The learning curve for mastering the laparoscopic technique is steep. Change in anatomical perspective and newer complications not encountered with open repair such as visceral injury, small bowel obstruction, port site hernia and subcutaneous emphysema has to be dealt with. Hence Laparoscopic hernia repair has been slow to gain acceptance.

Thus Inguinal hernia repair is an ever evolving field. This study aims at comparing the traditional open meshplasty with Laparoscopic meshplasty in our tertiary care center during these times where the world is slowly but steadily moving towards minimal access surgical procedures.

HISTORY OF INGUINAL HERNIA REPAIR

HISTORY OF INGUINAL HERNIA REPAIR

*In **Latin** the **word 'HERNIA' means is to tear or to "rupture"***. Historically inguinal hernia and its treatment has been a challenge to humanity and still remains the same even in modern times. ***The currently used term "HERNIA" comes from ancient Greece: kele/hernios in Greek means bud or offshoot***.

Written proof of the prevalence of Inguinal hernia is available from manuscripts and founds in **Mesopotamian and Egyptian cultures**. So does the **famous papyrus Ebers**, dating from around 1550 BC, refer to patients suffering from inguinal hernia, its appearance during coughing and straining.

Greco-Roman Times

The 'Old Masters' of **Greek and Roman** Antiquity elaborated on hernia pathology and devoted specific chapters to its origin, symptoms and treatment. It has reference in the Hippocratic Corpus as a specific disease entity.

The original manuscripts were transmitted and later rewritten in Roman times, by A***ulus Cornelius Celsus (fl.30-50 AD***) who shared knowledge on hernia in his 'De Re Medica', written around 30 AD.

Then later **Heliodorus (fl.125 A.D.)** denounced castration, and deals with the hernia sac by twisting its neck. **Galen (130-200)**, wound surgeon of gladiators and physician of Roman emperors, thought the origin of hernias to rupture of the peritoneum and overstretching of the overlying fascia and muscles. His treatment methods and teachings became medical Bible for several years since.

Middle Ages

With the fall of the Western Roman Empire in 476, **Byzantine** medicine took over Greco-Roman treatments, of Galen in particular. However **Paul of Aegina (ca.625-ca.690)** abstained from amputating the testicle but did herniotomy and reduced the contents or cauterized the skin, overlying the hernia, aiming at scarring the overstretched peritoneum.

Arab surgeons continued hernia treatments in line with Byzantine authors like **Aetius of Amida (502-575) or Paulus Aeginetus**. The most noted **Albucasis (936-1013)** discussed hernia at length in chapters of the 'Maqalat', the 30th book of his al-Tasrif.

Guy de Chauliac (1298-1368) borrow extensively from Albucasis' textbook but proposed different treatments. The surgical textbooks of Guy with a progressive preponderance for ***Guy's technique with the Golden Thread*** became a standard for next 300 years or so.

The Renaissance

Renaissance surgeons dared more than their medieval predecessors perform surgical interventions for inguinal hernia. **Pierre Franco (ca.1500-1561)** publish the first monograph, primarily devoted to herniotomy, and written in vernacular. Published in 1561 under the title 'Traité des hernies', Franco discusses in detail the nature, cause and treatment of different types of hernias including strangulated hernia.

The **German wound surgeon Kaspar Stromayr** (?-1566/67) published his 'Practica Copiosa', in which he elaborates on hernia treatment for the first time presents a differentiation between direct and indirect inguinal hernia.

French surgeon Ambroise Paré (1510-1590) took over Franco's account on hernia, and published it in 1564 without however citing his source.

Just like de Chauliac, Paré discussed various other methods of treatment, including cauterization but preventing orchidectomy.

17th and 18th Century

In the 17th century **Franco's** surgical treatments were followed and reiterated in most countries through the textbooks of **Paré**. After elaborate studies in anatomy **François Poupart (1661- 1709)** in 1695 recognized the importance the inguinal ligament in pathogenesis, described previously by **Gabriele Falloppio (1523-1562).** In the 18th century extensive studies of inguinal anatomical structures took place. First report of a successful transabdominal repair of inguinal hernia was published by **Demetrius Cantemir** (**1673-1723**) in 1716.

19th Century

In the 19th century anatomical studies revealed many fascias and ligaments known by the names of their discoverers: **Antonio Scarpa (1752-1832), Franz Kaspar Hesselbach (1759-1816), Thomas Morton (1813-1849), Alexander Thomson**. Scarpa described the intimate fusion of intestinal content with the peritoneal lining in a sliding hernia, thereby invalidating the theory of rupture of the peritoneum.

Sir Astley Paston Cooper (1768-1841) published new and original views on the inguinal canal in 1804 and 1807 and explained the importance of pectineal or superior pubic ligament and the transversal fascia. Italian surgeon **Eduardo Bassini (1844-1924)** reinforced the posterior wall by suturing the conjoined tendon to the inguinal ligament. The American surgeon **Henry Orlando Marcy (1837-1924)** introduced high ligature of the hernia sac, combined with narrowing of a dilated internal ring.

An original method of posterior inguinal wall repair, previously suggested by **Albert Narath (1864-1924)** and followed by the **Austrian Georg Lotheissen (1868-1935)**, consisted repair using the pectineal ligament of Cooper. This technique however was popularized in 1949 by **Chester McVay (1911-1987) and Barry Anson (1894-1874).**

20th Century

Newer anesthesia techniques enabled local cocaine infiltration first explained by the young surgeon **Harvey Cushing (1869-1939)** in 1898. In 1940's Canadian surgeon **Earle Shouldice (1891-1965)** of Toronto proposed a technique based on Bassini's repair consisting of a four layer muscular closure of the posterior wall.

Era of tension free repairs.

Already recommended by **Anton Wölfler (1850-1917)** in 1892**, William Halsted (1852-1922)** popularized this procedure, which was later adapted by **Norman Tanner (1906-1982)** by 'sliding' part of the rectus sheath lateral and downwards.

German Martin Kirschner (1879-1942), was the first to used autologous material to reduce tension. Non-autologous materials soon followed. In 1896 **Albert Narath (1864-1924)** used silver filigree. Years later **Francis Usher (1908-1980)** in 1958 *used polypropylene* as first successful synthetic prosthesis.

The tension free concept got its breakthrough in 1984 with **Irving Lichtenstein (1920-2000)** who realized tension-free repair by using prosthetic material to reinforce the posterior wall.

Posterior inguinal approach

George La Roque (1976-1934) in 1919 propounded idea of groin hernia repair in a preperitoneal position.. A totally extraperitoneal approach was first executed by **Cheatle in 1920**, as a radical cure for both inguinal and femoral hernia which was reiterated by **René Stoppa (1921-2006)** in France

LAPAROSCOPIC APPROACH

Ralph Ger was the first in 1982 to report a transabdominal closure of an inguinal hernia defect during a laparoscopy. Some years later, in 1989, the gynaecologist **S.Bogojavalensky** demonstrated the laparoscopic intraabdominal incision of the peritoneal hernia sac, subsequently closing the defect with mesh.

Since 1990 number of laparoscopic Hernia repairs started increasing employing techniques likr **Trans Abdominal Pre-peritoneal (TAPP), Totally Extra Peritoneal (TEP) or Intra peritoneal Onlay Meshplasty (IPOM).** The acceptance of laparoscopic hernioplasty started increasing worldwide.

AIM AND OBJECTIVES

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This study is aimed at comparative analysis of open tension free mesh repair technique **(LICHTENSTEIN'S)** and Minimally Invasive Laparoscopic mesh repair techniques **(TAPP or TEP)** for inguinal hernia at our tertiary Care center.

REVIEW OF LITERATURE

REVIEW OF LIERATURE

Development of Inguinal canal

The inguinal canal extends inferiorly and medially through the anterior abdominal wall, created by an outpouching of peritoneum, described as the processus vaginalis. During development gonads in both sexes must descend into the pelvis from the point of origin in the posterior abdominal wall. Mesenchymal cells condense to form the gubernaculum, which attach the caudal ends of the gonads, terminating in the inguinal region.

The pathway that the gubernaculum guides the descent of the gonads where in males the testis descend between the processes vaginalis, and the muscular layers of the anterior abdominal wall into the scrotal sac. The processus vaginalis normally regresses, with its distal part forming the tunica vaginalis, covering the surface of the testis failure of which can result in an indirect (congenital) hernia.

During male development, a collection of structures pass along the inguinal canal to form the testis, which include the ductus deferens, vessels and nerves which is contained in the spermatic cord, which is surrounded by three concentric layers of fascia derived from the anterior abdominal wall; internal spermatic fascia, cremaster muscle and the external spermatic fascia respectively, along with the ilioinguinal nerve.

In females the descent of the gonads is considerably less with gubernaculum attaching to primordial ovaries and the future labia majora. The ovaries lie laterally within the pelvic cavity, with gubernaculum forming the ovarian ligament and the round ligament, with the latter extending into the labia majora.

Inguinal Region Anatomy

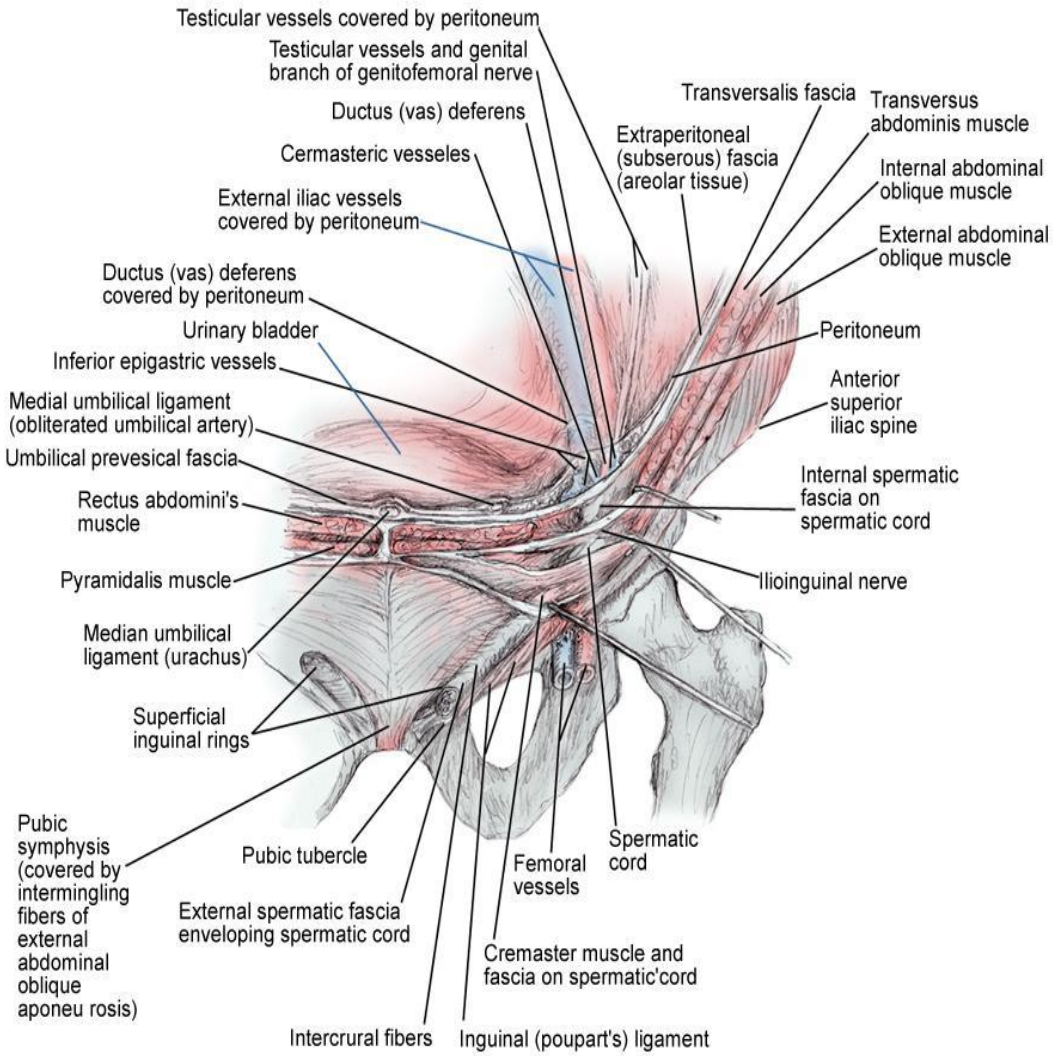


Fig: Inguinal region Anatomy

Anterior Abdominal wall

The abdominal wall formed by **nine overlying layers** which are the **skin, the subcutaneous tissue, the superficial fascia, the external oblique muscle, the internal oblique muscle, the transversus abdominis muscle, the transversalis fascia, the preperitoneal pad of fat & areola tissue** and **the peritoneum**.

Superficial fascia is has two layers: the **fatty outer layer, known as Camper's fascia**, and the deep **membranous layer, called Scarpa's fascia**.

The **fascia of Camper's** is areolar and contains in its meshes a varying quantity of adipose tissue. Camper's fascia is continuous inferiorly with the superficial fascia of the thigh.

The **fascia of Scarpa** is the deep membraneous layer of the abdomen found *deep* to the Fascia of Camper and *superficial* to the external oblique. n the midline it is adherent to linea alba and continue with the superficial fascia of the trunk. Inferiorly it is continuous with the Colle's fascia of the perineum. It does not extend to the thigh and is attached to fascia lata. Medially and below it is continued as Bucks fascia over the penis and spermatic cord to the scrotum, where it helps to forms the dartos muscle in males and labia majora in females.

The **external oblique muscle** originates from the lower seven ribs, from the thoracolumbar sheath, from the outer lip of the iliac crest and from the inguinal ligament. The muscle, anteriorly, near the midclavicular line, become a strong aponeurosis that passes anteriorly to the rectus muscle to insert into the linea alba. The inferior edge of the external oblique muscle aponeurosis forms the inguinal ligament (Poupart’s ligament) that is extended from the anterior superior iliac spine to the pubic tubercle.

The **internal oblique muscle** arises from the lower five ribs, from the thoracolumbar fascia, from the intermediate lip of the iliac crest and from the lateral half of the inguinal ligament. The lower fibers of the internal oblique muscle insert between the symphysis pubis and pubic tubercle. Some fibers, furthermore, form the cremasteric muscle.

The **transversus abdominis** muscle originates from the lower five ribs, from the thoracolumbar sheath, from the inner lip of the iliac crest and from the

lateral half of the inguinal ligament. Anteriorly, the muscle becomes an aponeurotic sheet that passes posteriorly to the rectus abdominis above the line of Douglas and anteriorly to the rectus muscle below the line.

The **transversalis fascia** is a continous layer which surrounds the entire abdominal cavity external to the peritoneum and contributes to the structural integrity of the abdominal wall covering the deep surface of the transversus abdominis muscle. Even though it is a continuous layer, it is known by different names in different areas, like trannscersalis fascia in the anterior abdominal wall, diaphragmatic facscia where it coevrs the diaphragm, at the fossa illiaca as illiac fascia and lumbar fascia in front of psoas and quadratus lumborum muscle. It forms the pelvic fascia at the pelvic floor. Thus it is single most important part of preventive mechanism of abdominal wall hernias.

The **aponeurosis of the External Oblique muscle** s a thin but strong membranous structure, the fibers of which are directed downward and medially. It covers the whole of the front of abdomen, superiorly gives raise to lower fibres of pectoralis major, inferiorly forming the inguinal ligament and the pectineal line, joining with opposite side aponeurosis to form Linea alba in the midline.

Inferiorly it gives rise to 4 different thickenings or ligaments which are key to Inguinal hernia repairs.

1. The **inguinal ligament** (**Poupart's ligament**) is a band running from the pubic tubercle to the anterior superior iliac spine. It forms the floor of the inguinal canal and important in repairs of inguinal hernia.

2. The **lacunar ligament** (**Gimbernat's ligament**) is a ligament in the inguinal region that connects the inguinal ligament to the Cooper's Ligament point where they both insert on the pubic tubercle.

3. The **reflected inguinal ligament** (**triangular fascia**) is a layer of tendinous fibers of a triangular shape, formed by an expansion from the lacunar ligament and the inferior crus of the subcutaneous inguinal ring.

4. The **pectineal ligament** (**inguinal ligament of Cooper)** is an extension of the lacunar ligament that runs on the pectineal line of the pubic bone and forms the posterior border of the femoral ring.

The **rectus abdominis muscles** act as the major abdominal wall stabilizer. They originate from the anterior surface of the fifth, sixth and seventh costal cartilages and the xiphoid process. Their insertions are on the superior aspect of the pubic crest just lateral to the pubic symphysis, and they are connected near the anterior midline by the linea alba.

The **rectus sheath** is formed by leaves of external, internal and transversus abdominal muscle aponeurosis and is an important structure which reinforces the anteriora bdominal wall. It enclosed **rectus abdominis and pyramidalis muscle**.

Anterior rectus above the arcuate line is comprised of external oblique and part of the internal oblique. The posterior rectus sheath is comprised of the internal oblique and transversalis fascia. Below the arcuate line, the external and internal oblique muscles fuse to form the anterior rectus sheath with the posterior rectus sheath made up of only transversus abdominis. In the midline anterior and posterior rectus sheath fuse to form the **Linea Alba.** Below the sheath are the transversalis fascia, Preperitoneal fat and parietal peritoneum.

The Inguinal Canal

The inguinal canals are situated just above the medial half of the inguinal canal on either side. The canals are approximately 3.75 to 4 cm long, extended between the internal ring and external ring angled anteroinferiorly and medially. It contains the ilioinguinal nerve together with spermatic cord in a male and the round ligament of the uterus in a female.

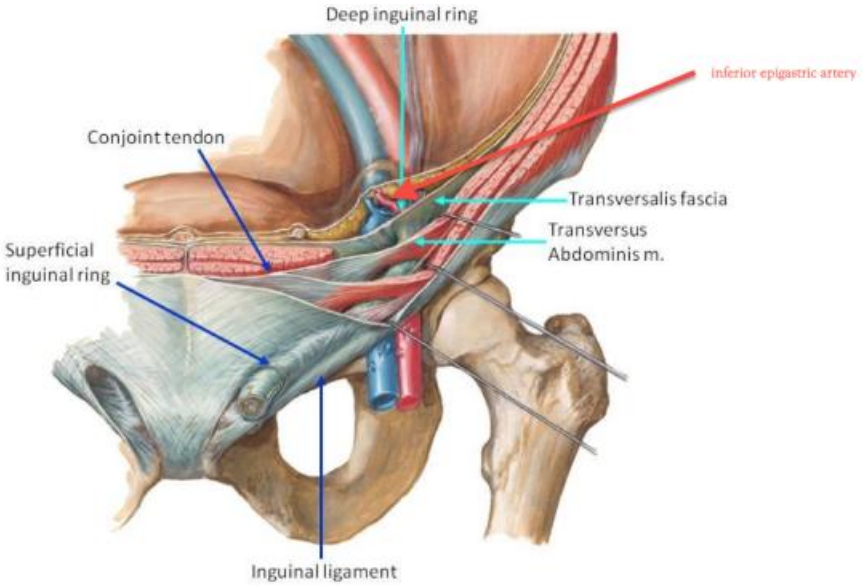


Fig: External and Internal ring with Inguinal canal.

Deep inguinal (internal) ring:

The deep inguinal ring is an oval opening, the beginning of the tubular evagination, located within the transversalis fascia located halfway between the anterior superior iliac spine and the pubic symphysis and approximately 1.3cm superior to the inguinal ligament. The spermatic fascia and the round ligament originate from this layer of transversalis fascia of the deep inguinal ring. It is immediately lateral to the inferior epigastric vessels.

Superficial inguinal (external) ring:

The superficial inguinal ring is a triangular-shaped defect in the aponeurosis of external oblique, with its base formed by the pubic crest and its apex pointing supero-laterally. It forms the end of the inguinal canal and is located superior to the pubic tubercle. To strengthen and support it the medial and lateral borders are held together by intercrural fibers located towards its apex.

The boundaries of the inguinal canal are:

Anteriorwall:
External oblique aponeurosis, fleshy part of internal oblique (lateral third of canal only) superficial inguinal ring (medial third of canal only)

Posterior wall:
transversalis fascia laterally , conjoint tendon medial third and deep inguinal ring (lateral third of canal only)

Superior wall (roof):
Musculoaponeurotic arches of internal oblique and transversus abdominis muscle

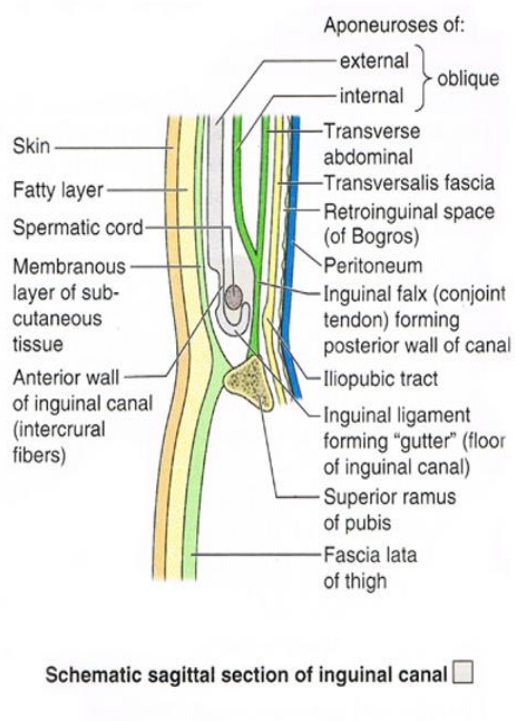


Fig: Inguinal canal: boundaries

Inferior wall (floor):

inguinal ligament, lacunar ligament (medial third of canal only), iliopubic tract (lateral third of canal only)

The structures which pass through the canals differ between males and females:

- in males: the spermatic cord and its coverings and the ilioinguinal nerve.
- in females: the round ligament of the uterus and the ilioinguinal nerve.

The contents of the spermatic cords in the male are:

Arteries: artery to vas deferens (or ductus deferens), testicular artery, cremasteric artery; **Fascial layers**: external spermatic, cremasteric, and internal spermatic fascia;

Nerves: genital branch of the genitofemoral nerve (L1/2), sympathetic and visceral afferent fibres.

Other structures: pampiniform plexus, vas deferens (ductus deferens), testicular lymphatics;

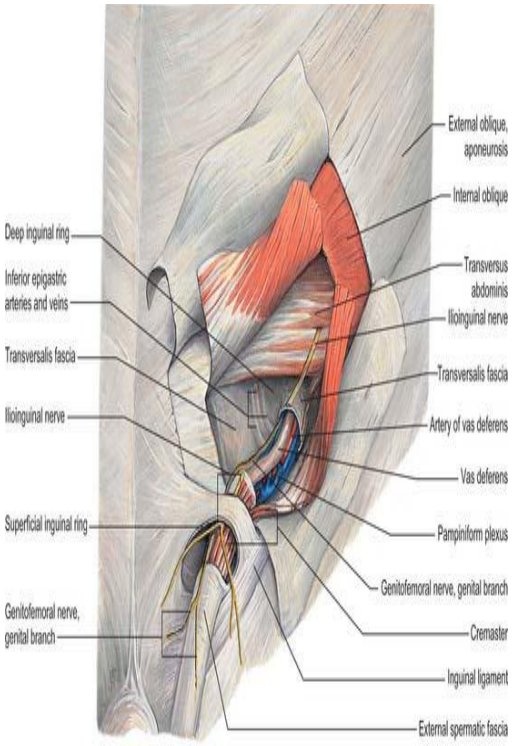


Fig: Contents of Inguinal canal & spermatic cord

Mechanics of the Inguinal Canal.

Inguinal canal is a potential weakness in the anterior abdomen and to maintain the intergrity a series of defense mechanism with shutter or musculoaponeurotic arcade formation happens.

First the **obliquity of the canal** with its openings at two different planes coursing through three separate abdominal musculature.

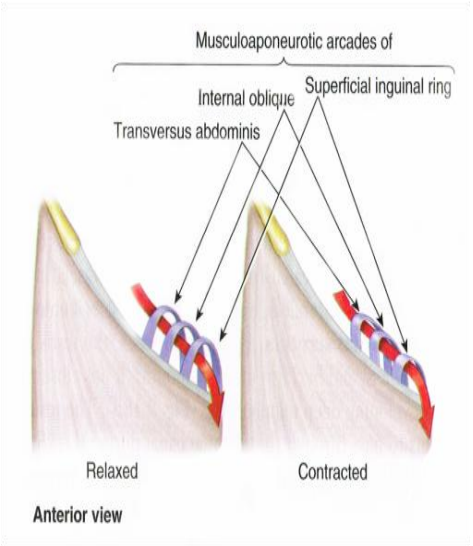


Fig: Mechanisms of inguinal canal

This produces a **flap valve mechanism** where the anterior and posterior walls of the canal gets approximated when intra abdominal pressure increases thereby preventing herniation. **Enlargement of the deep and superficial inguinal** rings can cause the oblique passage of the canal to be lost and increasing risk of herniation.

The inner shutter mechanism is the movement between transversus abdominis and the transversalis fascia. It is located at the deep inguinal ring at the layer of transversus abdominis, which works alongside the transversalis fascia and is thought to be the most significant in maintaining the canals integrity.

The **outer shutter** operates through the contraction of internal oblique and transversus abdominis inferiorly, which aids in closing the inguinal canal. The contraction of internal oblique closes the deep inguinal ring anteriorly pulling medial part of the transversus abdominis arch in an infero-lateral direction towards the inguinal ligament to act as a partial shutter.

Cremastric contraction helps the spermatic cord to plug the Internal ring **(Ball Valve Mechansim).** Contraction of External Oblique results in approximation of the two crura of the superficial ring **(Slit valve mechanism).**

A **U-shaped edge of the transversalis fascia**; the transversalis fascia sling is an opening in this layer, which acts as a tension mechanism. The medial crus of the transversalis fascia sling is attached to the aponeurosis and the lateral crus is attached to the posterior aspect of transversus abdominis. During muscle contraction the sling, which is inferior to the spermatic cord, is pulled in a supero-lateral direction closing the deep inguinal ring.

Laparoscopic Anatomy of the Inguinal Region.

Most surgeons are well versed with anterior open approach. Changing to Laparoscopic approach needs knowledge of the posterior approach.

Certain structures which are clearly visible during the open approach like illio-inguinal nerve, inguinal ligament, pubic tubercle and lacunar ligament are not directly visible with a laparoscope. But structures like Cooper's ligament and illio-pubic tract are clearly visible from inside.

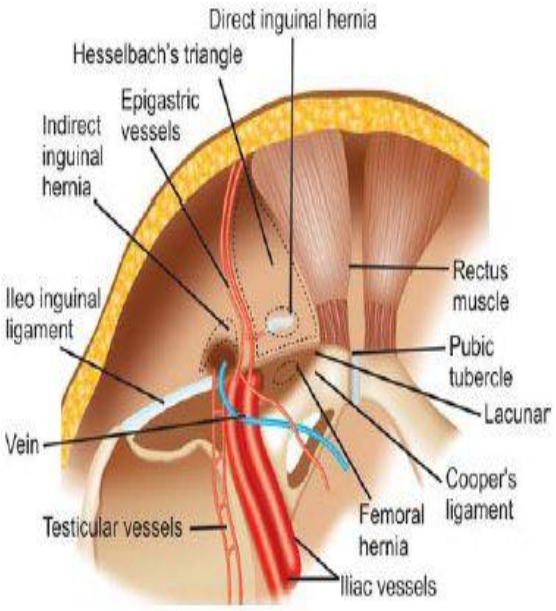


Fig: Inguinal region: Laparoscopic view

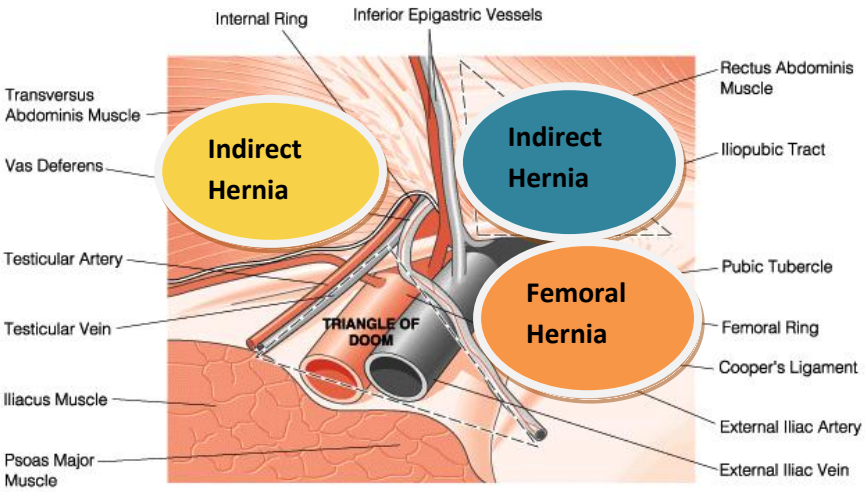


Fig: Left Inguinal Anatomy showing points of weakness

However Laparoscopic view is a "virtual view" with a 2 (two) dimensional handicap without a tactile feel.

Deep repair of inguinal hernia deals with the point of origin of hernias rather than point of presentation as in anterior approach. Thus the deep

posterior approach and repair deals with all the three potential hernial sites as seen in the "**Myopectineal Orifice of Fruchaud**"

In 1956, **Henry Fruchaud** propounded that all groin (inguino-femoral) hernias arise from a single weak area called **myopectineal orifice.** It is a potential space which is oval and funnel shaped with following boundaries:

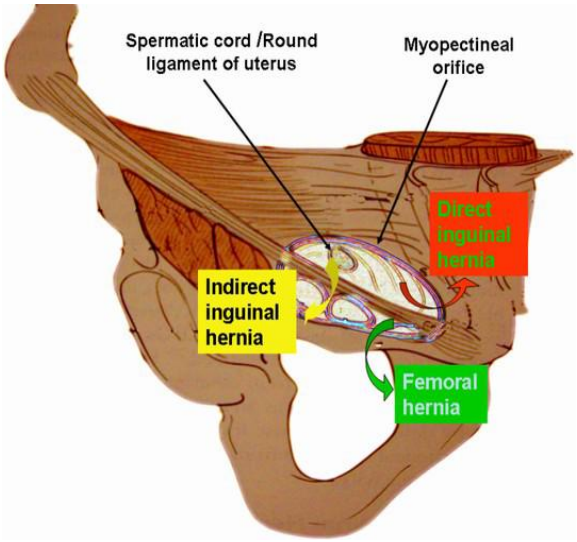


Fig: Myopectineal orifice

- **Superiorly:** Internal Oblique and Transverse abdominis muscles
- **Inferiorly:** Cooper's ligament (pecten pubis)
- **Medially:** by Rectus sheath and Muscle
- **Laterally:** Illio-Psoas Muscle.

The Orifice is divided into an "Inguinal defect" and "Femoral defect" by Illio-pubic tract. The critical anatomical landmarks such as Femoral vessels, Inguinal ligament and spermatic cord are all located here. This orifice is lined entirely by transversalis and its weakness results in all groin hernias as per Fruchaud.

Infra umbilical Fossae and Peritoneal Folds:

The infraumbilical fossae are important land marks for laparoscopic Inguinal hernia repair as they delineate the sites of herniation.

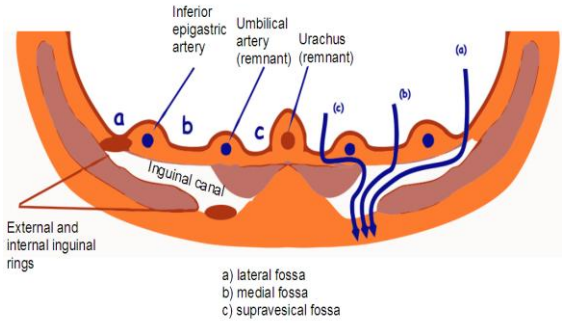


Fig: Intraperitoneal folds and fossae

They are made of peritoneal folds Median, medial and lateral umbilical folds.

- **Median Umbilical Ligament**: This is the urachal remnant arising from the bladder apex to the extends to the umbilicus. It ascends in the median plane.
- **Medial Umbilical Ligament**: This ligament represents the obliterated umbilical artery on either side and can be traced down to Internal Illiac artery.
- **Lateral Umbilical Ligament**: It is formed by a ridge of peritoneum formed by the Inferior Epigastric vessels during their course around the medial border of the deep inguinal ring towards the posterior rectus sheath.
- **Supravesical fossa:**
    - The infra umbilical area between the median and medial umbilical ligaments. This is the site of supravesical hernia.
- **Medial Umbilical Fossa:**
    - The infra umbilical area between the medial and lateral umbilical ligaments. This is the site of Direct inguinal and Femoral hernia.
- **Lateral Umbilical Fossa:**
    - The infra umbilical area lateral to lateral umbilical ligaments. This is the site of Indirect inguinal hernia.

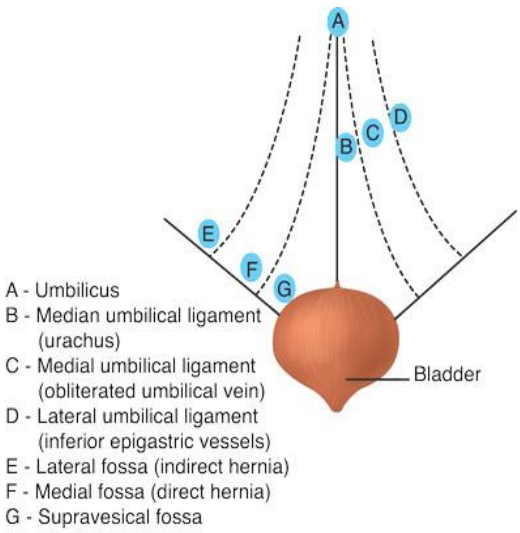


Fig: Infraumbilical ligaments & fossae

Hesselbach's (Inguinal) triangle:

Franz Kasper Hesselbach's (1751-1816) originally described the Inguinal hernia is bounded by

- **Medially:**by lateral border of the rectus Muscle
- **Laterally**: by Inferior Epigastric vessels
- **Inferiorly** : by Inguinal Ligament

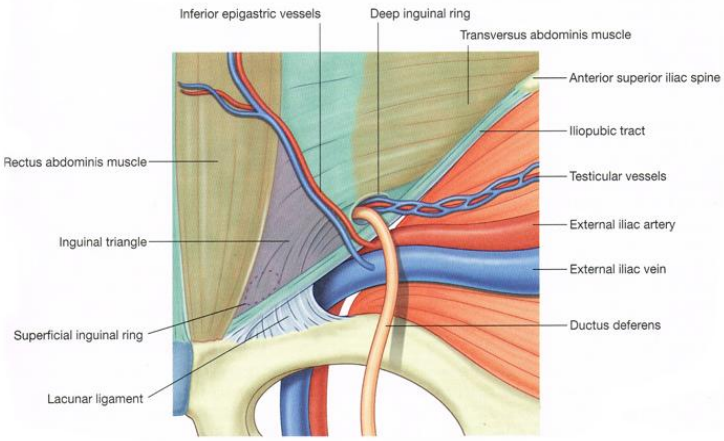


Fig: The Hesselbach's Triangle

The clinical significance is that the direct and femoral hernias leave the abdomen through this triangle.

The Pre-peritoneal Space:

The significance of pre-peritoneal space is the fact that all posterior approaches for inguinal hernia repair has to traverse this area and work. Hence a laparoscopic surgeon should have good knowledge of this space and its extensions.

It is bounded anteriorly by Transversalis facia and posteriorly by peritoneum.

Transversalis Fascia: The current understanding of pre-peritoneal space is very uch interlinked with the anatomy of the transversalis facia below the umbilicus. The fascia is bilaminar and superiorly it remains and distinct two layers and inferiorly it is attached to the Cooper's ligament. The anterior layer is attached to the rectus abdominus muscle and the posterior layer lies between the anterior layer and the peritoneum thus dividing the space into anterior

vascular space and posterior, Space of Bogros. The fascia remains as a bridge between transversus abdominis muscle and Cooper's ligament. This is the achille's heel of the groin and is the potential space through which Direct heriation happens.

The condensation of the transversalis arch forms three distinct structures

Interfoveolar Ligament: This forms the medial margin of the internal inguinal ring and is oriented vertically compared to the rest of the fascia. it is not of any significant strength.

Illiopubic Tract: It is the thickened lateral extension of the transversalis fascia, running from the superior pubic ramus to the illeopectineal arch and anterior superior illiac spine. The illiopubic tract separates the internal ring from the femoral ring. When doing a replaced mesh should not be tacked/stapled below the in lliopubic tract as it forms the supero-lateral boundary of the Triangle of pain through which the nerves of the illioinguinal region traverse.

Illeopectineal arch: is the key structure of the lateral groin which provides support and is thick tough fascial structure covering the illliac muscle arches and extends from the anterior superior Illiac spine to Illiopubic eminence.

The *vascular space* is situated between the posterior and anterior laminae of the transversalis fascia, and it houses the inferior epigastric vessels.

Space of Bogros: The posterior lamina of the transversalis fascia divides the pre-peritonel space into anterior vascular space and posterior "**Space of Bogros" described by French Anatomist Bogros in 1923.** Medially it is continous with the space of Retzius. Contains preperitoneal fat and areolar tissue.

Space of Retzius: The pre-peritoneal space which lies deep to the supravesical fossa and median fossa is named after **a Swedish Anatomist Retzius who described this space in 1858.** Dissection of this space is mandatory during the laparoscopic repair for proper mesh placement.

The pre-peritoneal space is filled with variable amount of connective tissue, fat, blood vessels nerves and lymphatics.

The preperitoneal anatomy seen in laparoscopic hernia repair led to characterization of important anatomic areas of interest, known as the ***triangle of doom*, the *triangle of pain*, and the *circle of death (Corona Mortis).***

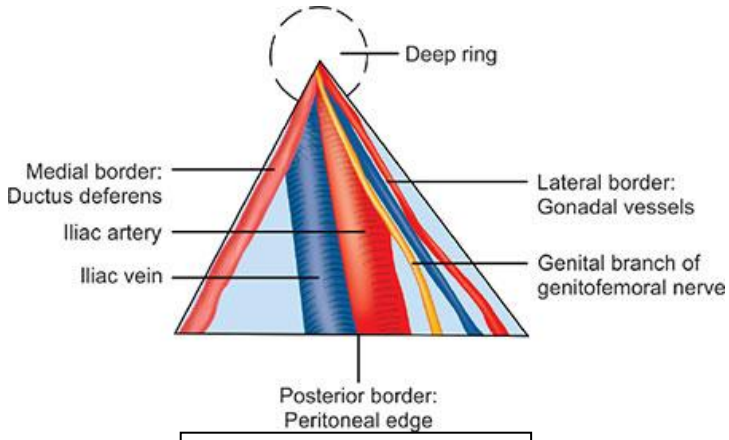
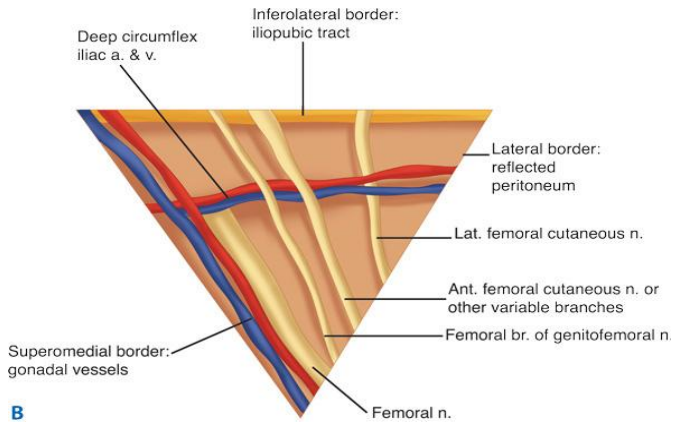


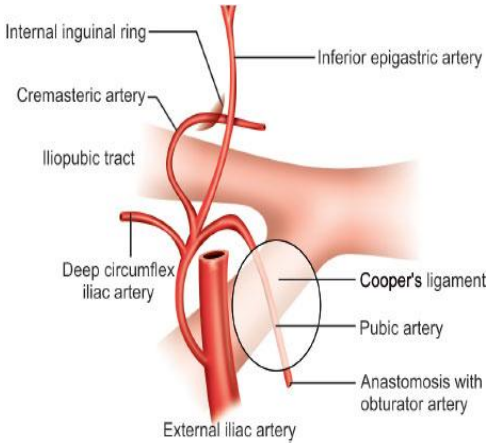
Fig: Triangle of doom

The triangle of doom is bordered medially by the vas deferens and laterally by the gonadal vessels. The contents of the space include the external iliac vessels, deep circumflex iliac vein, femoral nerve, and genital branch of the genitofemoral nerve.



The triangle of pain is a region bordered by the iliopubic tract supero-laterally and gonadal vessels medially, and it encompasses the lateral femoral cutaneous, femoral branch of genitofemoral, and femoral nerves.

Fig: Borders and contents of the (**B**) triangle of pain **(C)** Circle of death (below)



The circle of death is a vascular continuation formed by the common iliac, internal iliac, obturator, inferior epigastric, and external iliac vessels. in 25-30% of patients the anterior pubic branch which is arises from Inferior epigsatric artery is large and can replace the Obturator Artery. This aberrant obturator artery can partially encircle the neck of the hernial sac and can be injured during the repair. This can also be injured while exposing the Cooper's ligament free of fat and areolar tissue. Because of this possibility the anastomotic ring is called as **Corona Mortis.**

Vessels and Nerves in the Inguinal region:

There are numerous vessel and nerves coursing the inguinal region which when not properly identified and dealt with can lead to disastrous consequences during the repair of hernia , esp in the posterior approach. Hence the importance of understanding them. The most important structures are as below.

Arteries: External Illiac Artery with branches

- Inferior Epigastric Artery and its branches
- Deep circumflex Illiac artery

External Illiac Veins:

- Inferior Illiac epigastric veins
- Deep circumflex illiac veins
- Deep venous circulatory system

Nerves:

- Femoral Nerve

- Femoral and Genital branch of Femoral Nerve
- Lateral femoral cutaneous Nerve of thigh
- Illiohypogastric nerve
- Illioinguinal Nerve
- Sympathetic plexus

Lymphatics

- External illiac group of nodes and associated lymphatics

Incidence of Inguinal Hernias:

Hernias are a common medical problem and the their true incidence is not clear.

It is estimated that 5% of the population will develop an abdominal wall hernia, but the prevalence may be even higher (Malangoni and Gagliardi 2004). The lifetime risk of inguinal hernia is 27% in men and 3% in women. About 70-75% of all hernias occur in the inguinal region. Two thirds of these are indirect and the remainder are direct inguinal hernias. Femoral hernias comprise only 3% of all groin hernias.

Men are 25 times more likely to have a groin hernia than women. Indirect inguinal hernia is the most common type regardless of the gender. In men, indirect hernias predominate over direct hernias at a ratio of 2 : 1. Direct hernias are uncommon in women even though femoral hernias and umbilical hernias are more common in females. Inguinal hernias are still common in females although incidence of femoral hernias are higher in women than in men. Femoral hernias are rare in men.

Types of Inguinal Hernias

Inguinal hernias are classified as direct or indirect. The sac of an **indirect inguinal hernia** passes from the internal inguinal ring lies lateral to the Inferior epigastric vessels presenting anterolateral to the cord structures passing obliquely toward the external inguinal ring. At times it is extended into the scrotum. On the other hand the sac of a **direct inguinal hernia** usually presents in the Hesselbach's triangle protrudes outward and forward and is medial to the internal inguinal ring and inferior epigastric vessels. The differentiation is not much of importance as the operative repair of these are similar. At times an indirect and direct hernia **co-exists and is called a Pantaloon- type hernia**. As indirect hernias enlarge, it sometimes can be difficult to distinguish between indirect and direct inguinal hernias. This distinction is of little importance because the operative repair of these types of hernias is similar.

According to Causative factors:

Congenital or acquired.

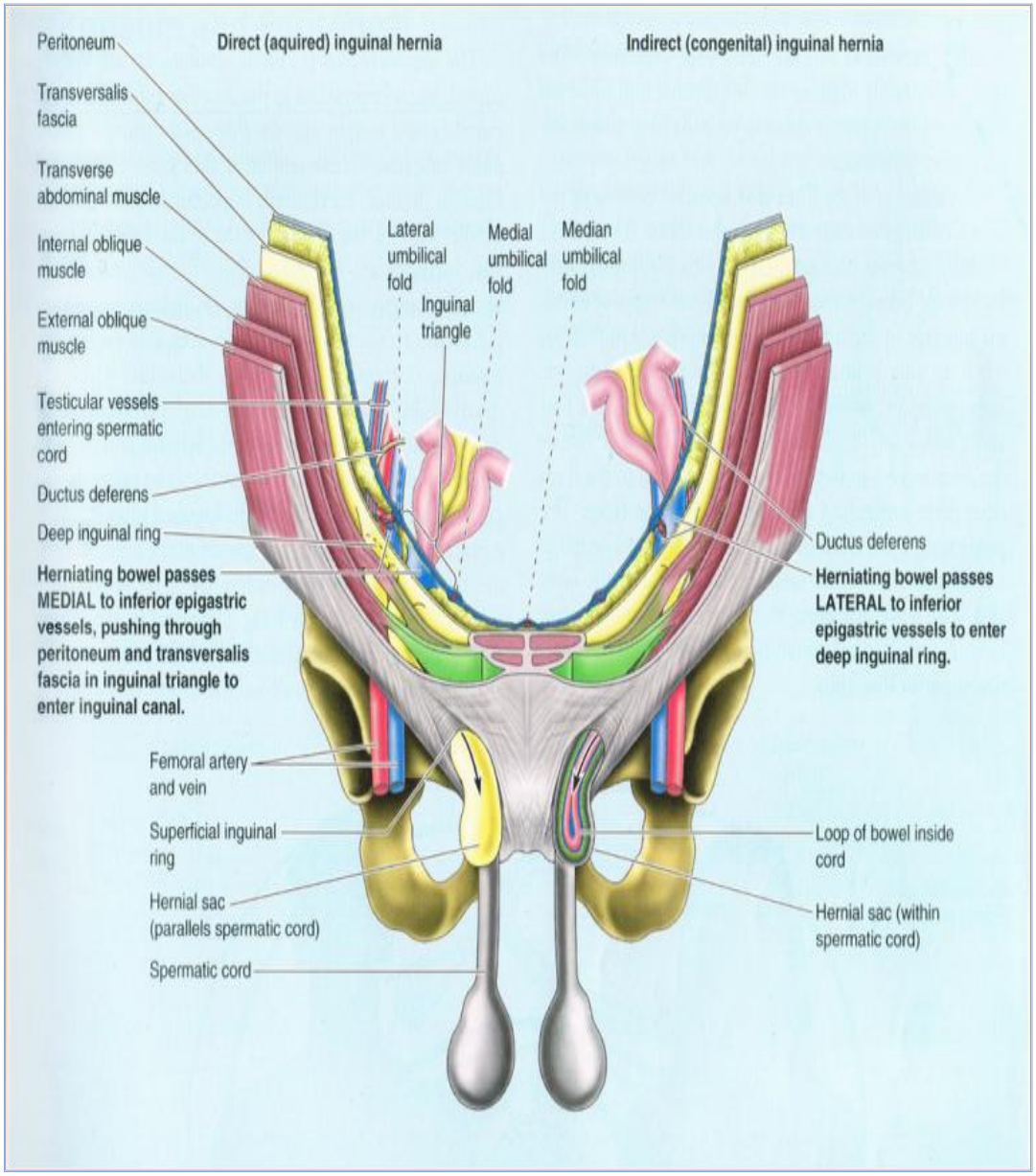
According to Extend:

- Bubonocoele: within the inguinal canal
- Funicular type: till the root of scrotum
- Scrotal or complete: extending to the base of scrotum.

Based on clinical presentation:

- Simple, Reducible
- Complicated:

  - Irreducible
  - Incarcerated
  - Obstructed
  - Strangulated



Etio-Pathogenesis of Inguinal hernias

Inguinal hernias can be congenital or acquired. The development of an inguinal hernia is multi factorial.

Congenital hernias, which make up the majority of pediatric hernias, can be considered an impedance of normal development due to descent of testes during the course from the intra abdominal origin into the scrotum

preceded by gubernaculum and a diverticulum of peritoneum. The peritoneum which accompanies gubernaculum forms the processus vaginalis and usually closes at around 36-40 weeks thereby eliminating the communication with peritoneum at the internal ring. Failure of the closure leads to persistent processus vaginalis (PPV) resulting in high incidence of congenital inguinal hernias in pre-tem babies. However, a patent processus does not necessarily indicate an inguinal hernia. It is assumed that 12-15% of adults have patent Processus vaginalis, but without suffering an inguinal hernia. However the risk of inguinal hernia increased by 4 fold in the presence of contra lateral PPV in 5 years.

Most **adult inguinal hernias are considered acquired defects** in the abdominal wall in which case it may be caused by a dehiscence of the fascias accompanied by a loss of abdominal wall strength. Etiologic factors may be increased intra-abdominal pressure or changes in the connective tissue (Conze et al. 2001).

During the episodes of increased intra abdominal pressure the abdominal wall maintain the integrity in spite of pre-formed weakened areas due to various mechanisms on the inguinal canal. In addition, the transversus abdominis aponeurosis flattens during tensing, thus reinforcing the inguinal floor. However any condition when the intra abdominal pressure is raised over prolonged periods can predispose to Inguinal hernias.

Muscle paralysis or injury can disable the shutter effect. A congenitally high position of the aponeurotic arch may preclude the buttressing effect. Neuropraxic or neurolytic sequelae of appendectomy or femoral vascular procedures may increase the incidence of hernia in these patients. Acquired Muscle weakness and fascia of the anterior abdominal wall is associated with physical strain, advancing age, sedentary life habits, smoking, adiposity,

constipation, prostatism, chronic obstructive pulmonary diseases, ascites, multiple pregnancies, lower quadrant abdominal surgeries etc all can predispose inguinal hernias.

Abnormal collagen metabolism is thought to play an important role in the development of primary inguinal hernia. An increase of type III collagen, (the thin isolated fibers) leads to a decreased ratio of type I, (the thick fiber bundles) to type III collagen. This alters the physical properties and the strength of the collagen matrix of the abdominal wall, and may predispose individuals to development of inguinal hernias. For example, Collagen disorders such as Ehlers-Danlos syndrome and Marfan's syndrome are associated with an increased incidence of hernia formation.

Special types of Inguinal Hernias.

Sliding Hernia

A sliding hernia occurs when an internal organ comprises a portion of the wall of the hernia sac. The most common viscus involved is the colon or urinary bladder. Most sliding hernias are a variant of indirect inguinal hernias, although femoral and direct sliding hernias can occur. The primary danger associated with a sliding hernia is the failure to recognize the visceral component of the hernia sac before injury to the bowel or bladder. The sliding hernia contents are reduced into the peritoneal cavity, and any excess hernia sac is ligated and divided before repairing the hernia.

Recurrent Hernias

Can happen with both tissue based repairs and Mesh based repairs. However tissue based repairs are more prone for recurrence. The recurrent hernias pose fresh challenges for management as the anatomy is distorted with adhesions around with or without mesh. Recurrent hernias almost always require placement of prosthetic mesh for successful repair. Recurrences after

anterior hernia repair without mesh previously can be repaired by both anterior or posterior approach. But recurrence after anterior mesh placement is best managed by a laparoscopic or open posterior approach, with placement of a second prosthesis or vice-versa.

Bilateral Hernias

The approach of bilateral inguinal hernioplasty is based on the extent of the hernia defect. Simultaneous repair of bilateral hernias is found to have similar recurrence rate to unilateral repair, regardless of the approach. Alternatively the use of a giant prosthetic reinforcement of the visceral sac (Stoppa repair) can be tried. Laparoscopic repair is generally recommended as simultaneous repair of bilateral inguinal hernias can be attempted without additional incisions.

CLASSIFICATION OF INGUINAL HERNIAS

There are many classifications of Inguinal hernias. Even though the purpose of these classifications are to provide uniformity for surgeons to communicate and to allow comparisons and treatment options, they remain incomplete. Still most Surgeons continue to describe hernias with respect to type, location and volume of the sac.

Gilbert Classification (1989)

In 1989, Gilbert published his classification system on anatomic and functional defects established intra operatively based on the presence or absence of a peritoneal sac, the size of the internal ring, and the integrity of the posterior wall. Rutkow and Robbins added the combined direct and indirect hernia and the femoral hernia to this classification system (Rutkow and Robbins 1993).

***Type I*:** Hernia has got snug internal ring through which a peritoneal sac passes out as indirect sac.

Type II: Hernia has a moderately enlarged internal ring which admits one finger but is lesser than two finger breadth. Once reduced it protrude during coughing or straining.

Type III : Hernia has got large internal ring with defect more than two fingerbreadth. Hernia descends into the scrotum or with sliding hernia. Once reduced it immediately protrudes out without any straining.

Type IV: It is direct hernia with large full blow out of the posterior wall of the inguinal canal. The internal ring is intact.

Type V: It is a direct hernia protruding out through punched out hole/ defect in the transversalis fascia. The internal ring is intact.

Type VI: Pantaloon/double hernia.

Type VII: Femoral hernia.

TYPE VI and VII are Rutkow & Robbin's modifications.

NYHUS CLASSIFICATION (1991)

Nyhus used anatomic criteria, e.g., size of the internal ring and integrity of the posterior wall, to classify theinguinal hernia (Nyhus 1991)

Type	Description	
Type I	Indirect hernia with normal deep ring.	
Type II	Indirect hernia with enlarged deep ring; but the posterior wall is intact. Inferior deep epigastric vessels not displaced.	
Type III	Posterior wall defect.	
	a	Direct with posterior wall defect only
	b	Pantaloon hernia: Indirect with posterior wall weakness.
	c	Femoral hernia.
Type IV	Recurrent hernia.	

AACHEN CLASSIFICATION (1995)

The Aachen classification is based on the diameter of the hernial orifice and its position.

Aachen classification (Schumpelick and Arlt 1995)

Classification	Type	Size	
L	Lateral hernia	I	Hernia orifice < 1.5 cm
M	Medial hernia	II	Hernia orifice 3 cm
Mc	Combined hernia	III	Hernia orifice >3cm
F	Femoral hernia		

ZOLLINGER CLASSIFICATION (2003)

In 2003, Zollinger presented a modified traditional classification that included all the classes or grades within the Nyhus-Stoppa, Gilbert, and Schumpelick- Arlt systems. This modified classification grades the size of the hernia in small, medium, and large using “fingertips” or “fingerbreadths” for measurement. The large indirect hernia is characterized by a disrupted internal ring that is greater than 4 cm or two fingerbreadths in width, whereas the large direct hernia is defined by a complete blowout of the entire floor(Zollinger 2003).

Modified traditional classification (Zollinger 2003)

I	A	Indirect small
	B	Indirect medium
	C	Indirect large
II	A	Direct small
	B	Direct medium
	C	Direct large

III Combined

IV Femoral

O Other Any not classified by number above

Femoral + indirect or direct

Femoral + indirect + direct

Massive > 8cm (4 fingers)inguinal defect

Prevascular

R Recurrent

EHS Classification.

The European hernia society [EHS] has an official classification for groin hernias which is good, simple and easy to remember. This classification mentions both anatomical location and size of the hernia orifice as seen intra-operatively. It localizes the hernia anatomically as L = lateral, M = medial, F = femoral and measures the size of the hernia orifice using the tip of the index finger which is about 1.5-2cm.

EHS Groin Classification system					
	Primary/ Recurrent				
	0	1	2	3	X
Lateral (L)					
Medial (M)					
Femoral (F)					

0 = No hernia detectable
1 = <1.5 cms (one finger)
2 = <3 cms (more than two fingers)
3 = > 3ms (three fingers)
X = not investigated.

Example:

Thus a primary indirect inguinal hernia with a 3 cms defect size would be PL 2 hernia. This dimension is reported to be identical to the length of branches of a pair of most laparoscopic graspers, dissectors, or scissors enabling the surgeon to use the same classification during laparoscopic surgery. In this classification, combined hernias are ticked in the appropriate boxes. The drawback is that this classification cannot be used pre-operatively.

Treatment of Inguinal hernias

Non operative management.

Most surgeons recommend operation on discovery of a symptomatic inguinal hernia for fear of progressive enlargement and weakening, with potential for irreducibility, incarceration and strangulation. However watchful waiting is a time tested strategy in old asymptomatic patients who have increased risk associated with surgery. Patients electing non-operative management can occasionally have symptomatic improvement with the use of a truss. Even though hernia control has been reported in about 30%of patients; complications such as testicular atrophy, ilioinguinal or femoral neuritis, and hernia incarceration were associated with this approach.

Femoral hernias are always managed surgically as they are notorious for obstruction and strangulation.

Surgical management:

Anterior approach:

Anterior repairs are the most common operative approach for inguinal hernias. They are broadly **tissue repairs** and **tension free repairs** using mesh or Prosthesis. Majority are Tension-free repairs which has replaced many tissue repairs. Older tissue types of repair are rarely indicated, except for

patients with simultaneous contamination or concomitant bowel resection, when placement of a mesh prosthesis may be contraindicated.

Tissue repairs

Although tissue repairs have largely been abandoned because of unacceptably high recurrence rates, they remain useful in certain situations. In strangulated hernias, for which bowel resection is necessary, mesh prostheses are contraindicated and a tissue repair is necessary. some of the available options for tissue repair include Desarda's repair, iliopubic tract, Shouldice, Bassini, and McVay repairs. Shouldice is still considered in young adults. Newer method of tension free tissue repair, Desarda technique is gaining traction.

The major developments in the history of tension repairs of inguinal hernia Summarized in the below table

Author	Year	Technique
Edoardo Bassini	1887	Reconstructing the anatomy of the inguinal canal by suturing the transversus abdominis and internal oblique musculoaponeurotic arches or conjoined tendon (when present) to the inguinal ligament.
William Steward Halsted	1889	approximates the transversus abdominis aponeurosis to the iliopubic tract and the shelving portion of the inguinal ligament Subcutaneous position of the spermatic cord
Chester Mc Vay	1942	Cooper’s ligament instead of inguinal ligament for the reconstruction
Edward Earl Shouldice	1953	Multilayer imbricated repair of the posterior wall of the inguinal canal with a continuous running suture technique
Nyhus LM	1993	Illiopubic tract repair by approximating the transversus abdominis aponeurotic arch to the iliopubic tract
Mohan Desarda	2001	repair method using an undetached strip of external oblique aponeurosis

Tension-Free Anterior Inguinal Hernia Repair

The tension-free repair has become the dominant method of inguinal hernia repair where a prosthetic mesh is placed to bridge the defect, a concept popularized by Lichtenstein.

In the **Lichtenstein repair**, a piece of prosthetic non-absorbable mesh is fashioned to fit the canal with a slit is cut into the distal lateral edge of the mesh to accommodate the spermatic cord. The mesh is to the pubic tubercle medially and continuously to the inguinal ligament inferiorly, conjoint tendon superiorly and laterally fish tailing done.

Other popular Mesh based repairs are as below.

Table-: Techniques in tension free repair- summary.

Author	Year	Technique
Francis Usher	1959	Reinforcing Bassini Technique with mesh
Irvin Lichtenstein	1984	Placing the mesh to reinforce the posterior wall of the inguinal canal
Arthur Gilbert	1987	Cone & plug to cover defect
Ira Rutkow and Alan Robins	1998	Plug and patch repair
Arthur Gilbert	1999	Prolene Hernia systems

The **sandwich technique** involves a bilayered device, with three polypropylene components. An underlay patch provides a posterior repair similar to that of the laparoscopic approach, a connector functions similar to a plug, and an onlay patch covers the posterior inguinal floor.

The **Stoppa Repair, first described by** Rene Stoppa in 1975, is a tension-free type of hernia repair with mesh placement over the pre-peritoneal layer. It is performed by wrapping the lower part of the parietal

peritoneum with prosthetic mesh and placing it at a pre-peritoneal level **over Fruchaud's myopectineal orifice**. This operation is also known as "**giant prosthetic reinforcement of the visceral sac" (GPRVS)** .

Laparoscopic posterior approach Inguinal hernia repairs

The laparoscopic approach provides the mechanical advantage of placing a large mesh behind the defect covering the myopectineal orifice and using the natural forces of the abdominal wall which retains the mesh in place.

The transabdominal preperitoneal repair (TAPP) was first described in 1991 by Arregui. Here the peritoneal cavity is entered, the peritoneum is dissected from the myopectineal orifice, mesh prosthesis is secured, and the peritoneal defect is closed.

In the totally extraperitoneal (TEP) approach, the dissection begins in the preperitoneal space using a balloon dissection but maintains peritoneal integrity, theoretically eliminating these risks while allowing direct visualization of the groin anatomy, which is critical for a successful repair. The TEP hernioplasty follows the basic principles of the open preperitoneal giant mesh repair, as first described by Stoppa in 1975 for the repair of bilateral hernias.

MESHES COMMONLY USED

Meshes Used in Inguinal Hernia Repair:

As hernias is a structural problem resulting in weakness of the abdominal musculature, repair by reinforcing the weakness using surgical meshes is considered most appropriate. Thus Surgical mesh strengthen tissue repair and minimize the rate of recurrence**..** As compared to tissue repairs the Meshplasty reduced the recurrence rates tremendously as per several randomized controlled studies . Mesh should not be fixed under tension.

An ideal mesh should be easy to handle, flexible, strong, immunologically inert and resistant to contraction. It should also infection resistant with ability to form local inflammatory response with scarring to prevent further herniation. It should resist shrinkage or degradation over time with no restriction on future access. Moreover it should be easy to manufacture and affordable for community use. Thus in selecting mesh material, considerations include mesh absorbability, thickness, porosity, weight, tensile strength and less tissue reactivity in general.

There are **heavy weight and light weight meshes** based on the fiber diameter and variations in the fiber count of mesh. Ideally one should choose a monofilament light-weight mesh with large pores and minimal surface area. Synthetic materials like **Polypropylene and Polyester** are the most common synthetic prosthetic materials used in inguinal hernioplasty. These materials are permanent and hydrophobic, and they promote a local inflammatory response that results in cellular infiltration and scarring with slight contraction in size. They tend to reduce scarring and chronic pain with equivalent recurrence rates as compared to heavy weight ones. **These meshes are ideal for use where they do not come in contact with the abdominal viscera, viz, open**

(Lichtenstein's) as well as laparoscopic repairs of inguinal hernias - TAPP or TEP.

Biologic Mesh

The development of biologic mesh largely has derived from the need of biocompatible material that addresses the problems associated with a permanent synthetic mesh which includes chronic inflammation, foreign body reaction, fibrosis, and mesh infection. There are numerous biologic materials available made of organic biomaterial such as porcine dermis, porcine small intestine submucosa, bovine dermis or pericardium, and the dermis or fascia lata of a cadaveric human. In general, they have lower tensile strength and subsequent higher rates of rupture than synthetic prostheses. Currently its use is restricted to specific instances as there remains a lack of sufficient evidence to guide clinical practice regarding the use of biological mesh products. Another drawback include the high cost of the material vis a vis its clinical effectiveness. For these reasons currently BIOMESH usage is not a popular one and more RCTs are awaited to prove its clinical usefulness in day to day practice.

Mesh Complications in brief:

FOREIGN BODY REACTIONS

Meshes of all variety tend to produce inflammatory response once inside the body. All meshes cause a foreign body reaction which has an effect on the ratio of Type I and III collagen synthesized. The maximum inflammatory response occurs between 7 to 21 days after fixation. Several studies have proven the evidence of chronic inflammation of varying degrees even after couple of years of fixing the mesh. This leads to adhesion formation and destruction of adjacent structures vas deferens etc. t can also lead to tissue ischemia and infection of tissues.

INFECTIONS

In some cases, Mesh can get infected due to contamination or spread of infection from neighboring tissues. Infection is common with contaminated wounds. The meshes at lowest risk of infection are those made with monofilament and containing pores greater than 75 μm. Infections can appear as quickly as two weeks after surgery, or as long as 39 months post-surgery. Symptoms of a hernia mesh infection can include Pain, Fever with chills, Tenderness, Swelling with local inflammatory signs. These infections can cause subcutaneous infections, discharging fistulas or intra-abdominal abscess. Infections can often be treated with antibiotics. But, in some cases, patients will require additional surgery to remove the surgical mesh. With routine use of prophylactic antibiotic intra operatively the incidence of such infections are less. use of Biomesh is however associated with increased risk.

HERNIA MESH CAN MIGRATE AND SHRINK

The surgical mesh may shrink, stretch, or even migrate from its original position. It isn't just the material of the surgical mesh that can cause complications, but also its size and location. Once implanted, mesh may shrink, stretch, or even migrate from its original position. This can perforate and injure the intestines, bowels, and other nearby organs. If the weakened tissue is left inadequately supported, the hernia can recur. Recurrent hernia repair surgeries though have higher risk of developing complications than the first operation. Shrinkage is inevitable due to contraction of tissues by dehydration and invasion by myofibroblasts even with good technique. Subsequent collagenization and remodeling can further augment this process.

PAIN

Pain remains a serious complication of mesh repair even though the incidence is lesser compared to tissue repair. This is thought to be related to the ability to use tension-free technique rather than the mesh itself. The immediate

postoperative pain many times are due to nerve damage and tissue handling. In contrast, pain due to foreign body reaction (FBR) typically presents late and is more chronic and debilitating. Explants removed for chronic pain have nerve fibers and fascicles around the foreign body granuloma with neuroma formation suggesting more tissue degradation. It follows that meshes with small pores and greater Foreign body reaction invariably produces higher rates of chronic pain.

MESH DEGRADATION

Degradation of meshes is rare and mainly seen in polyester meshes. Degradation may be due to hydrolysis, resulting in brittleness and loss of mechanical strength. Calcification can occur but is common in meshes with small pores.

RECURRENCE due to Mesh Failure

Meshes are thought to reduce incidence of hernia recurrence as compared to tissue repairs. The rates are as low as 0.2 for Lichtenstein's repair to as high as 11% for TAPP & TEP especially with inexperienced Laparoscopic surgeons. However the recurrence rates were drastically reduced with experience. Medial recurrence is common which occurs at the edges of meshes. This is due to inadequate fixation, or underestimation of shrinkage of the mesh. Although it has been proposed that light-weight meshes have a higher risk due to their increased flexibility and movement this is a matter of debate. Known risk factors include postoperative infection, seroma and haematoma are risk factors of poor wound healing and recurrence. Two-thirds of recurrences occur after 3 years (median, 26 months). This suggests that a technical error is unlikely to be the only cause of recurrence and defective collagen synthesis may be equally important.

COMPLICATIONS OF INGUINAL HERNIA REPAIR

The most common complications of inguinal hernia repair include bleeding, seroma, wound infection, urinary retention, ileus, and injury to adjacent structures. Complications specific to herniorrhaphy and hernioplasty include hernia recurrence, chronic inguinal and pubic pain, and injury to the spermatic cord or testis.

Hematomas

Hematomas may present as localized collections or as diffuse bruising over the operative site. Although they are self-limited, characteristic dark blue discoloration of the entire scrotum may alarm patients. Injury to spermatic cord vessels may result in a scrotal hematoma. Hematomas may also develop in the incision, retroperitoneum, rectus sheath, and peritoneal cavity. The latter three sites are more frequently associated with laparoscopic repair. Bleeding within the peritoneum or preperitoneal space may not be readily apparent on physical examination. Hence close monitoring of subjective complaints, vital signs, urine output, and physical parameters is necessary in the post operative period. Intermittent warm and cold compression aids in resolution.

Seromas

Seromas are loculated fluid collections that most commonly develop within 1 week of synthetic mesh repairs. Large hernia sac remnants may fill with physiologic fluid and mimic seromas. Patients often mistake seromas for early recurrence. It is better not to aspirate as it may introduce secondary infection with deleterious effects to mesh unless it is extremely uncomfortable for the patient. Treatment consists of reassurance and warm compression to accelerate resolution.

Surgical Site Infection

As inguinal hernias are clean surgeries, the risk for surgical site (wound) infection is estimated to be 1% to 2% after open inguinal hernia repair and less with laparoscopic repairs. However there is risk if associated conditions are prevalent and based on the immune status. The placement of prosthetic mesh does not increase the risk for infection as per several studies and hence may not need antibiotic prophylaxis. Some mesh infections will present as a chronic draining sinus that tracks to the mesh or occur with extruded mesh. Superficial surgical site infections are treated by opening the incision, local wound care, and healing by secondary intention. Deep surgical site infections can involve mesh which then need to be explanted. Prophylaxis is better than cure by employing proper technique including hemostasis, pre-op antiseptic skin preparation, appropriate hair removal and hygiene. If there are any skin infections, this needs to be managed before surgery.

Nerve Injuries and Chronic Pain Syndromes

Nerve injuries can occur per operatively and occur due to traction, transection, entrapment or due to electrocautery. use of prosthetic meshes altered sensations which may be uncomfortable initially but will disappear in time. The nerves most commonly affected during open hernia repair are the ilioinguinal, genital branch of the genitofemoral, and iliohypogastric nerves. During laparoscopic repair, the lateral femoral cutaneous and genitofemoral nerves are most often affected and tackers should not be placed in the triangle of pain. Rarely, the main trunk of the femoral nerve can be injured during open or laparoscopic inguinal hernia repair. Transient neuralgias can occur and are usually self-limiting, but persistent neuralgias can cause hyperesthesia and burning sensation locally at the area of distribution. Transection of a sensory nerve results in an area of numbness. At times movement or pressure by garments will cause symptoms. Post-herniorrhaphy inguinodynia is a debilitating chronic complication caused by a combination of nociceptive,

neuropathic,and visceral elements. Its incidence is independent of the method of hernia repair; however, the original operative technique determines options for intervention and remedial surgery.

Various approaches to management of residual neuralgia exists. Early symptoms are treated with anti inflammatory agents, analgesics, and local anesthetic nerve blocks. Patients with nerve entrapment syndromes are best treated by repeat exploration with neurectomy and mesh removal through an anterior approach. Laparoscopic nerve injuries are minimized by not placing any tacks or staples below the lateral portion of the iliopubic tract. If nerve entrapment occurs, patients undergo reoperation to remove the offending tack or staple.

Hernia Recurrence

When a patient develops pain, bulging, or a mass at the site of an inguinal hernia repair, clinical entities such as seroma, persistent cord lipoma, and hernia recurrence should be considered. Large population-based studies have reported a recurrence rate of 4% to 5% in the first 24 months, which increases to 7.5% at 5 years. Hernia recurrences are usually caused by technical factors, such as excessive tension on the repair, missed hernias, failure to include an adequate musculo-aponeurotic margin in the repair, failure to close a patulous internal ring and improper mesh size and placement. Mesh displacement is also a cited cause. Other complimentary factors that can cause hernia recurrence are chronically elevated intra-abdominal pressure, chronic cough, malnutrition, immuno suppression, diabetes, steroid use, deep incision infections, smoking and poor collagen formation in the wound. Medial recurrences are common after direct hernioplasty near the pubic tubercle and this involves the floor. This is due to suture line tension. Currently tension free mesh repair has addressed this issue.

Radiological examinations like USG, CT or MRI will complement well an ambiguous clinical picture in a problematic patient. After an initial anterior approach, the posterior laparoscopic approach is recommended for repair of recurrence. Conversely, failed Laparoscopic repairs should be managed using an open anterior repair. Recurrences are best managed by placing a mesh through a different approach. An approach through a virgin plane facilitates easier dissection and exposure without injuring the adjacent vital structures.

Ischemic Orchitis and Testicular Atrophy

Injury to spermatic cord structures may result in ischemic orchitis or testicular atrophy. Ischemic orchitis is likely caused by injury to the pampiniform plexus than the testicular artery. It usually manifests within 1 week of inguinal hernia repair as an enlarged, indurated, and painful testis, and it is almost certainly self-limited. Injury to the testicular artery also may lead to testicular atrophy, which is manifest over a protracted period.

Injury to the Vas Deferens and Viscera

Injury to the vas deferens and intra-abdominal viscera are rare. Most of these injuries occur in patients with sliding inguinal hernias with failure to recognize the presence of intra abdominal viscera in the hernia sac. Either manipulation during anterior approach or grasping while dissection in Laparoscopic approach can result in injury and at times may lead to infertility.

Laparoscopic Hernioplasty Complications.

There are some specific complications associated with laparoscopic inguinal hernia repairs. In general, the risks of the TEP technique mirror those of open anterior repairs, as the peritoneal space is not violated. Post placement complications are common for both techniques.

Complications of transabdominal laparoscopy include urinary retention, paralytic ileus, visceral injuries, vascular injuries, and less commonly, bowel obstruction, hypercapnia, gas embolism, and pneumothorax.

The other most common complications of laparoscopic inguinal hernia repair are :

Urinary Retention. The most common cause of urinary retention after hernia repair is general anesthesia in laparoscopic hernia repairs and to with open surgeries employing spinal anesthesia. Other risk factors for postoperative urinary retention include pain, narcotic analgesia, and peri-operative bladder distention. This can be prevented by placing a urinary catheter before surgery and can be removed later in the day. Once identified this condition can be treated by short time cathetization.

Ileus and Bowel Obstruction. The laparoscopic transabdominal approach is associated with a higher incidence of ileus than other modes of repair. This complication is self-limiting but might require sustained inpatient monitoring, intravenous fluid maintenance, and possibly nasogastric decompression.

Visceral Injury. Small bowel, colon, and bladder are at risk for injury in laparoscopic hernia repair. Direct bowel injuries may result from trocar placement. The presence of intraabdominal adhesions from past surgeries may also predispose. Bowel injury may also occur secondary to electrocautery and instrument trauma outside of the camera field. In reoperative abdominal surgery, open Hasson technique and direct visualization of trocars are recommended. If injury to the bowel is suspected conversion to open repair may be necessary.

Bladder injuries are less common than visceral injuries, and they are usually associated with perioperative bladder distention or extensive dissection of perivesical adhesions. If identified cystotomies should be performed and repaired in two layers after urinary decompression using Foley's catheter.

Vascular Injury. The most severe vascular injuries usually occur in iliac or femoral vessels, either by misplaced sutures in anterior repairs, or for inferior epigastrics and external iliacs by trocar injury or direct dissection in laparoscopic repairs. Conversion to an open approach may be necessary as bleeding may be severe. Bleeding should be temporarily controlled with mechanical compression until vascular control is obtained. At times missed bleeding may be inapparent or can cause delayed rectus hematoma. The inferior epigastrics may be ligated with a percutaneous suture passer or endoscopic hemoclips if injured.

Hematomas and Seromas are common complication after laparoscopic hernia surgery, the incidence being in the range of 5 to 25 percent.

Hematomas develop in the incision site, retro peritoneum, rectus sheath, and peritoneal cavity are more frequently associated with laparoscopic repair. Bleeding within the peritoneum or preperitoneal space may not be readily apparent on physical examination. For this reason, close monitoring of the patient is important in the first post operative day.

Seromas after laparoscopic hernia surgery are common than open method and the incidence being in the range of 5 to 25 percent. They are especially seen after large indirect hernia repair. Most resolve spontaneously over 4 to 6 weeks. A seroma can be avoided by minimizing dissection of the hernia sac from the cord structures, fixing the direct sac to pubic bone and fenestrating the transversalis fascia in a direct hernia. If there is excessive bleeding or extensive dissection a drain can be placed.

RATIONALE FOR THE STUDY

RATIONALE FOR THE STUDY

Inguinal hernias are one of the commonest surgical conditions encountered in general surgical practice worldwide with more than 2 million procedures done annually. As it stands now both Lichtenstein's open tension free meshplasty and minimally invasive laparoscopic meshplasty techniques are evidence-based and accepted methods with unique advantages and drawbacks for adult hernioplasty. However it has not been easy for high throughput tertiary government teaching institutions to embrace technology and sophisticated instruments due to cost and economies of scale.

However we need to move with the times without compromising quality and the training needs. There is a growing demand for laparoscopic procedures. In our quest for betterment and in accordance with our moto of continuous learning and improvement we wanted to evaluate these two techniques to be adopted in our community safely. Hence the study aims at comparing the traditional open meshplasty with Laparoscopic meshplasty in our tertiary care center during these times where the world is slowly but steadily moving towards minimal access surgical procedures.

While the results of similar comparison is well documented in the literature, the present study is an attempt to examine whether the observations and results are same when attempted in our institution, given that operations are performed by surgeons with varying levels of interests and expertise in the procedure and also by trainee residents under supervision.

MATERIALS AND METHODS

MATERIALS AND METHODS

Study Population:

In patients of Govt. KMC hospital are included in the study.

Type of Study and duration:

Prospective study for a period of one year between March 2017 till March 2018.

Type of participants:

The study included patients with a diagnosis of uncomplicated inguinal hernia for whom mesh repair was judged appropriate.

Age group: between 20-75 years.

Inclusion Criteria :

- Patients who present with unilateral or Bilateral inguinal hernias
- Patients with uncomplicated inguinal hernias
- Patients with recurrent inguinal hernias
- Patients with ASA I ,II, III categories
- Patients with no evidence of infection
- Patients with no risk factors which may delay wound healing

Exclusion Criteria:

- Patients with complicated inguinal hernia (irreducible, obstructed, strangulated inguinal hernia)
- Patients with ASA IV,V, E categories
- Patients who are converted from laparoscopy to open
- Patients with bleeding diathesis
- Patients not willing for surgery

Types of interventions : (Methods of surgical repair of inguinal hernias)

- ✓ All laparoscopic procedure shall be performed by either "Transabdominal Pre-peritoneal method' of hernioplasty" (TAPP) or "Total Extra Peritoneal" (TEP) method.
- ✓ All open procedure by 'Lichtenstein's tension free open mesh repair'.

Sample size:

The study included a total of 50 patients who presented with uncomplicated inguinal hernias after excluding the complicated hernias. Of these 25 patients were operated by Lichtenstein's Open mesh repair technique and another 25 patients with Laparoscopic Trans Abdominal pre-peritoneal or Totally Extra Peritoneal technique.

Method of Study and Sampling Technique

Data Collection Included, Name, age and sex of the patient, IP number and occupation with documentation of presenting complaints with duration, detailed history present illness, past history, occupation history, etc shall be collected. Then Complete physical examination, Laboratory investigations, Radiological investigations wherever necessary, procedure performed, post op analgesia required, Complications and Duration of hospital stay.

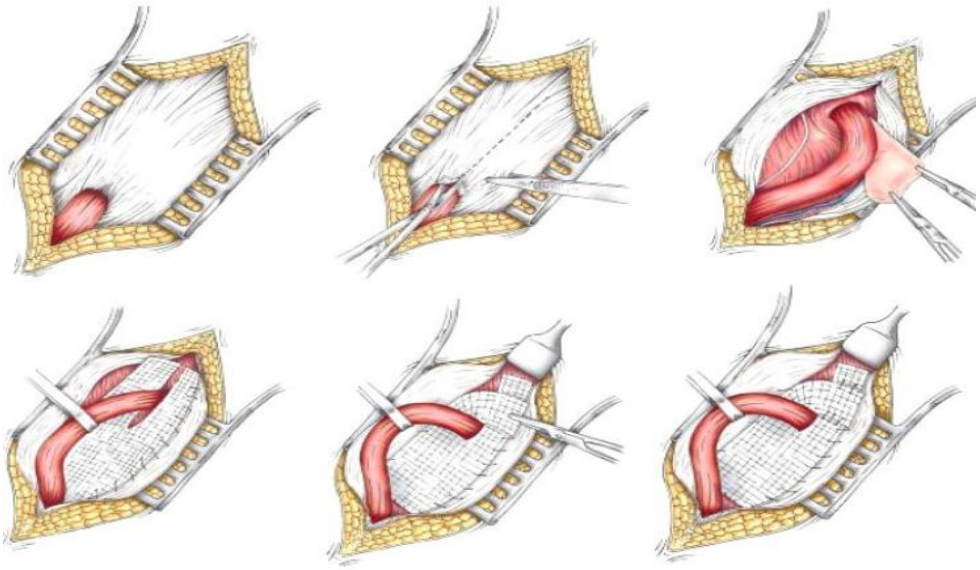
Criteria to compare laparoscopic and open inguinal hernioplasty at our center:

- ✓ Duration of surgery.
- ✓ Intra operational complications
- ✓ Degree of postoperative pain.
- ✓ Incidence of post operative complications
- ✓ Duration of hospital stay.
- ✓ Duration to resume normal activity of daily living.
- ✓ Duration to return to work.
- ✓ Recurrence rates at 6 months following surgery.

SURGICAL INTERVENTION TECHNIQUES

SURGICAL INTERVENTION TECHNIQUES

Detailed Steps of Lichtenstein's tension free open mesh repair.

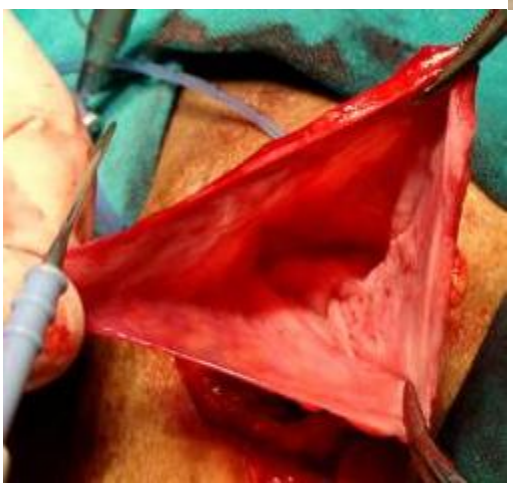


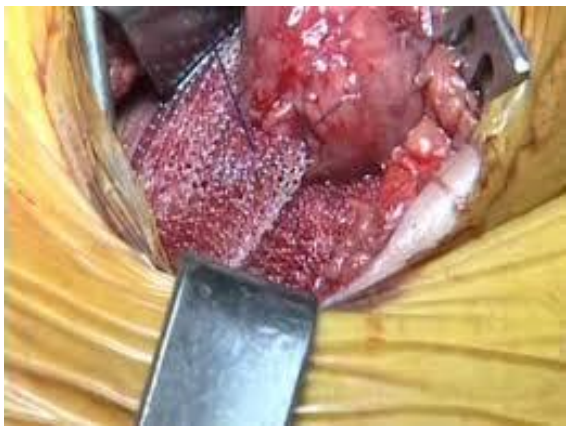
A

naesthesia: All patients undergoing open hernioplasty under spinal or regional anesthesia (SA/RA).

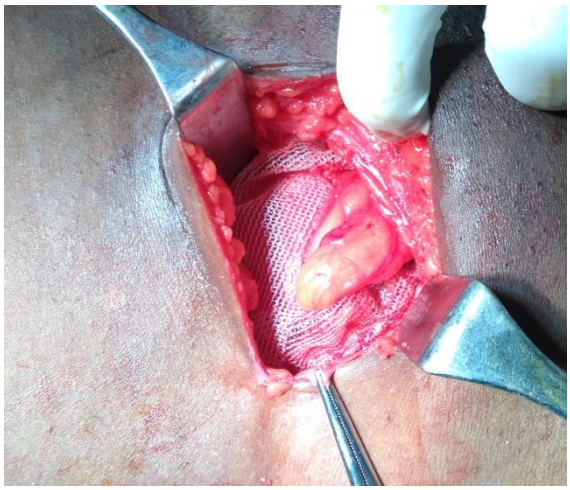
Incision: Transverse incision made half an inch above the inguinal ligament towards the medial two third and deepened. Two layers of superficial fascia, outer Camper and inner Scarpa's fascia are incised. External oblique aponeurosis is identified by its shining fibers and exposed before incising with No 15 scalpel blade or cautery. Medially it is extended up to the external ring to open it. Two leaves of the aponeurosis are elevated to visualize the conjoined tendon above and Inguinal ligament below.

Ilioinguinal nerve is safeguarded after careful dissection. Cremaster muscle (cremaster box) is opened. Medial dissection is done beyond the pubic tubercle. Hernial sac is identified which is pearly white in colour. Fundus, body





Open Tension Free Meshplasty in Pictures



and neck of the sac are dissected using scissor or cautery. Cord is held using hernia ring (Collingwood Stewart and kept aside.

Cord is dissected 2 cm beyond the pubic tubercle. Neck of the sac is identified by its narrow area, being lateral to inferior epigastric vessels and by presence of extraperitoneal pad of fat. Sac is dissected *high up above* the level of the internal ring; sac is opened on the summit of the fundus; all contents are reduced; sac is twisted adequately so that no contents will return back to the sac during ligation; sac is transfixed high above the internal ring using 3 zero vicryl or monocryl and ligated. Redundant sac is excised to complete the herniotomy. The distal part of the sac is left in situ open.

Polypropylene mesh is used for repair (10 × 6 cm size); size is decided based on the width of the defect. Suturing of mesh is done using interrupted non absorbable monofilament polypropylene sutures below to inguinal ligament, superiorly to the conjoint tendon.. Laterally Fish tailing has to be done by dividing the mesh at a ratio of 1:3 and 2:3 and cord is enclosed within the divided mesh.

Cord and ilioinguinal nerve is placed back in the inguinal canal. Complete hemostasis attained. External oblique is sutured using absorbable vicryl sutures. Subcutaneous interrupted sutures are placed. Skin is closed with nonabsorbable 3 Zero interrupted sutures. Waterproof dressing is placed.

Detailed description of Laparoscopic hernia repair.

Anesthesia: Laparoscopic Inguinal hernia repair is ideally performed under General Anesthesia.

Position of Surgical Team: Surgeon stands towards the opposite side of the hernia near the shoulder. Camera assistant should stand either right to the patient or on the opposite side of the patient.

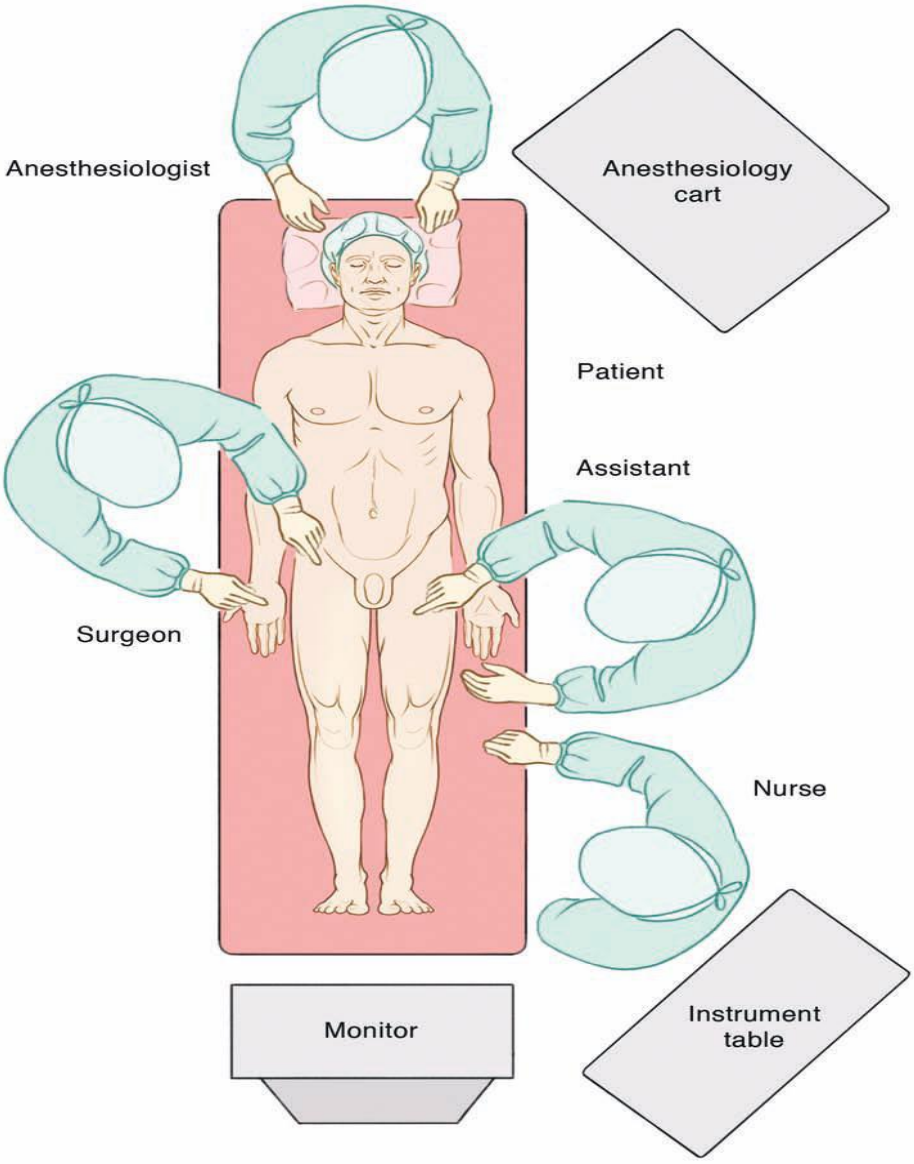
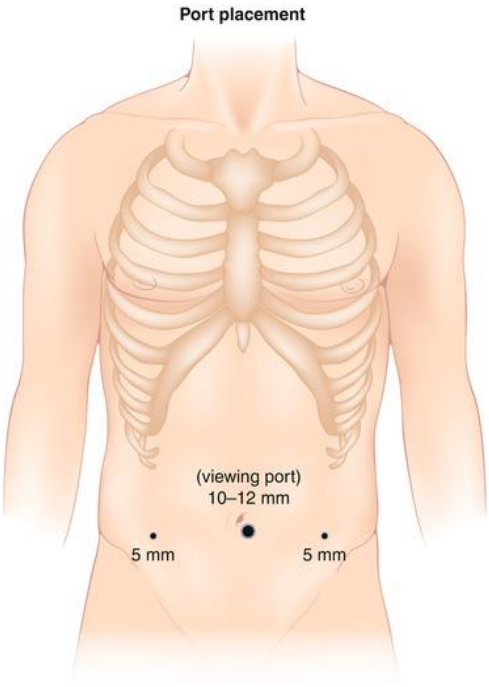


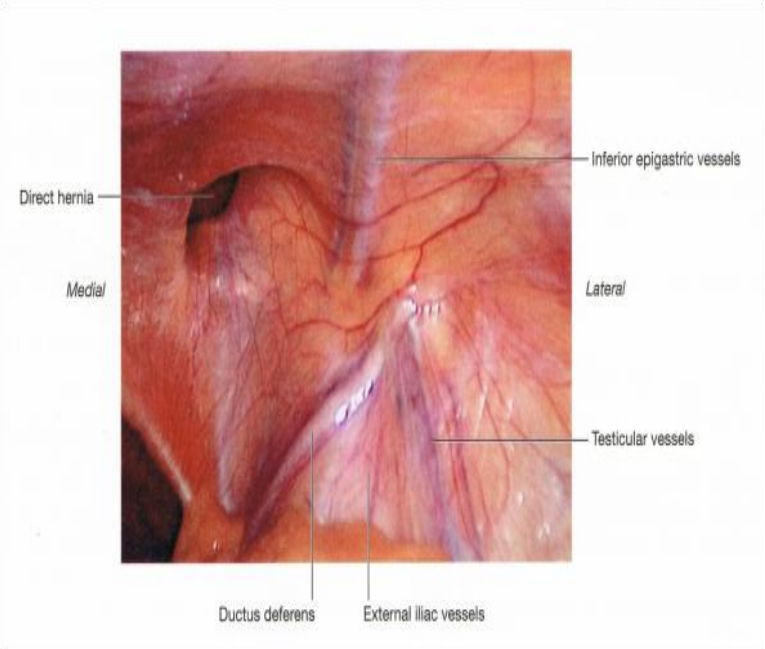
Fig: Schematic representation of Surgical team position and instrument panel

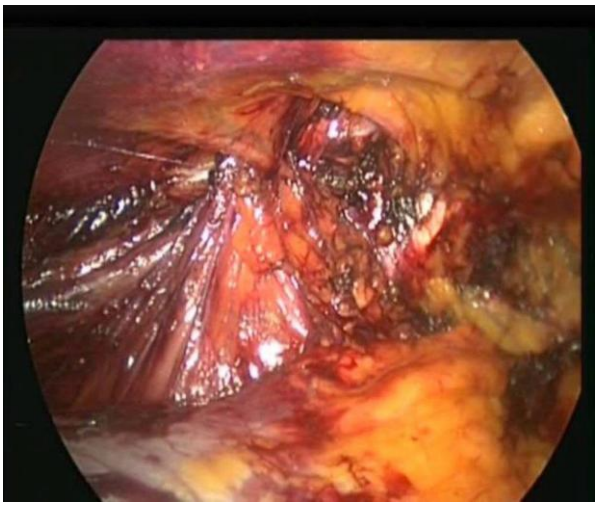
TRANSABDOMINAL PREPERITONEAL REPAIR OF INGUINAL HERNIA (TAPP)

Port Position



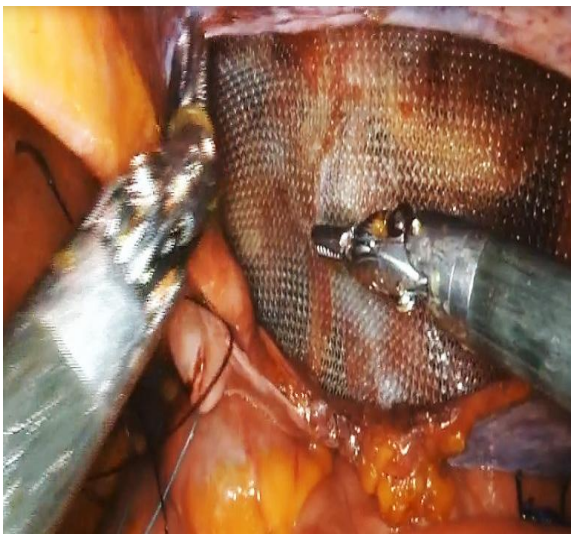
The position of port is laparoscopic repair of trans-abdominal hernia repair should be according to base ball diamond concept. 30º telescope is better choice for laparoscopic hernia surgery. A 10 mm umbilical port is used as telescopic port. Two other ports, usually 10 mm for dominant hand and 5 mm for non dominant hand, are placed lateral to the inferior epigastric artery at the level of umbilicus. In a left sided hernia the right lateral port should be in right iliac fossa and left port in left hypochondrium so that both the instrument should make a manipulation angle of 60°. In right sided hernia surgery right port should move up towards hypochondrium and left port will come down to make the triangle.



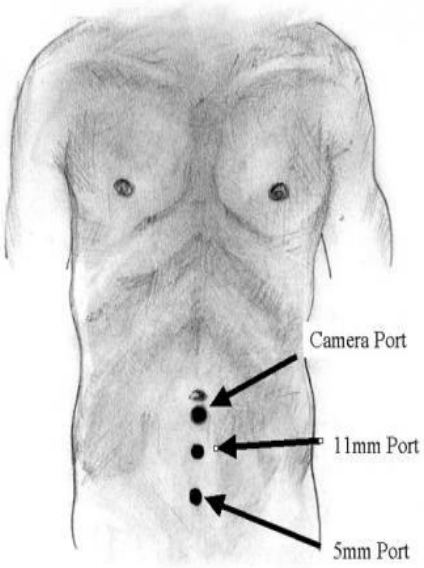


A peritoneal flap is created high on the anterior abdominal wall, extending from the median umbilical fold to the anterior superior iliac spine. A direct hernia sac and associated preperitoneal fat are gently reduced by traction if not already reduced by balloon expansion of the peritoneal space. A small, indirect hernia sac is mobilized from the cord structures and reduced into the peritoneal cavity. A large sac may be difficult to reduce. In this case, the sac is divided with cautery near the internal inguinal ring, leaving the distal sac in situ. The proximal peritoneal sac is closed with a loop ligature to prevent pneumoperitoneum from occurring.

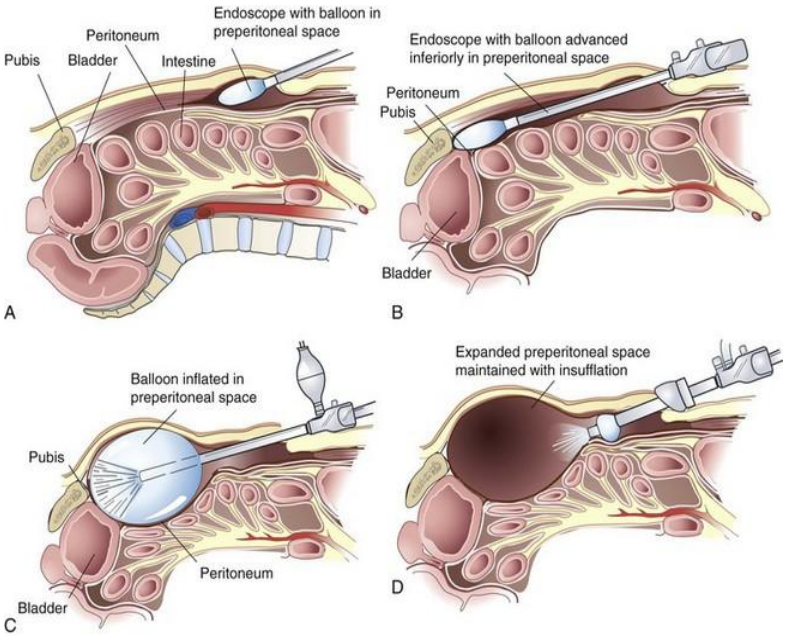
After all hernias are reduced, a 12-×14-cm piece of polypropylene mesh is inserted through a trocar and unfolded. It covers the direct, indirect, and femoral spaces and rests over the cord structures. It is imperative that the peritoneum be dissected at least 4 cm off the cord structures to prevent the peritoneum from encroaching beneath the mesh, which can lead to recurrence. The mesh is carefully secured with a tacking stapler to Cooper's ligament from the pubic tubercle to the external iliac vein, anteriorly to the posterior rectus musculature and transversus abdominis aponeurotic arch at least 2 cm above the hernia defect, and laterally to the iliopubic tract. The mesh extends beyond the pubic symphysis and below the spermatic cord and peritoneum.



TOTALLY EXTRA-PREPERITONEAL REPAIR OF INGUINAL HERNIA (TEP)



Port position: The first 11-mm port is placed using an open technique. A subumbilical transverse skin incision is made and then advanced slightly off the midline. The 11-mm balloon-tip port is then inserted bluntly into the preperitoneal space and inflated. A 10-mm, 30°-angle laparoscope is inserted. A balloon dissector should be introduced with telescope and balloon is inflated for further dissection of the preperitoneal space.



In the TEP approach, an infraumbilical incision is used. The anterior rectus sheath is incised, the ipsilateral rectus abdominis muscle is retracted laterally, and blunt dissection is used to create a space beneath the rectus. A dissecting balloon is inserted deep to the posterior rectus sheath, advanced to the pubic symphysis, and inflated under direct laparoscopic vision. After it is opened, the space is insufflated and additional trocars are placed. A 30-degree laparoscope provides the best visualization of the inguinal region. The inferior epigastric vessels are identified along the lower portion of the rectus muscle and serve as a useful

landmark. Cooper's ligament must be cleared from the pubic symphysis medially to the level of the external iliac vein. The iliopubic tract is also identified. Care must be taken to avoid injury to the femoral branch of the genitofemoral nerve and lateral femoral cutaneous nerve, which are located lateral to and below the iliopubic tract . Lateral dissection is carried out to the anterior superior iliac spine. Finally, the spermatic cord is skeletonized before completing the Mesh placement.

The technique of insertion of mesh in totally extraperitoneal repair of hernia is same as that of transabdominal preperitoneal. Mesh of appropriate size usually 15 × 15 cm is used and rolled and loaded backward in one of the port. Mesh should be fixed by stapling first in its middle part three finger above the superior limit of the internal ring. In totally extraperitoneal repair some surgeon do not use staple, because peritoneum is not breached and once the gas from preperitoneal space is removed, it will place the mesh in its proper position.

Intra-operative monitoring

The following observations were made:

- Time taken for procedure. Operative time calculated from the time of incision to the time of closure.
- Anesthetic complications
- Documentation of any complications encountered during the procedure like Port placement issues, Neurovascular, bladder, bowel or visceral injury.
- If laparoscopic procedure was converted to open, then reasons for conversion.

POST OPERATIVE EVALUATION AND MANAGEMENT

Postoperative Care before discharge

Post operatively patients were supplemented with intravenous fluids before starting orally. They also were given parenteral antibiotics, Cefrtiazone 1 gm twice a day and Metrogyll 500 mg three times a day intravenously for first 72 hours. This was followed by Cap. Cephalexin 500 mg three times a day for three days.

From the first postoperative day all patients will be given parenteral analgesic either an NSAID with Paracetamol or Tramadol injection. A note will be made using the visual analogue scale (VAS) of severity of pain. This was done three times a day for two postoperative days while patient is admitted. On the third day they were given NSAIDS orally if the pain score was between 4 and 6 (VAS). No drugs were given if the score was less than 4.

- The patient were encouraged active mobilization as soon as they can.
- All patients were admitted for three days for accurate evaluation and documentation of the severity of pain.
- The wound site was checked for soakage in the immediate post operative period till next day.
- The abdomen, Testes, scrotum, penis and perineum were examined twice in the first 24 hours and once thereafter for the time patient was in the hospital. When the patient came for follow up in the OPD again a thorough examination was done and recorded.
- Patients were questioned regarding paraesthesia or altered sensation in groin area.

- Wound infection shall be diagnosed, based on the presence of purulent discharge from the wound or organism grown from swabs taken from the wound, in case wound was required to be opened due to severe redness or induration.

- Patient was discharged on the third post operative day if there were no immediate post operative complications and is patient is otherwise fit to be discharged.

Patient follow up following discharge:

- Pain measured by Visual Analogue Scale (VAS).
- Wound infection.
- Any complication related to the procedure
- Resumption of daily activity.
- Time required to return to work.

Patients of both groups were followed regularly up to 6 months. They are scheduled for follow up visits in the outpatient at 7 ± 2 days, 8 ± 1 weeks, and 6 ± 1 months after surgery. During this time patients are questioned regarding the presence of complication and their subjective satisfaction with hernia repair experience. The time of return to work was noted. Any discomfort or functional delay questioned and recorded as observation.

In patients with persistent discomfort, or if full recovery was not achieved at the 8-week visit, extra visits were performed at intervals of 4 weeks until full recovery was noted.

The patient is encouraged to return to his normal work as soon as he found himself able. There were no restrictions on physical activity, other than the patient's own experience of pain and discomfort. If the patient's work

involved strenuous physical activity, he will be advised light work if this was permissible in these terms of employment.

Time to full recovery and to end of sick leave was noted by the patient in a self-administered record form. The time to full recovery shall be defined as when inguinal discomfort did not interfere with normal daily or athletic activities.

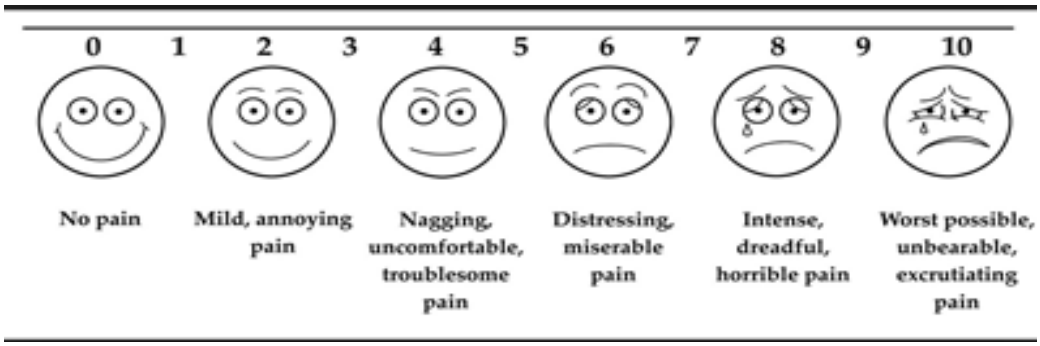
Hernia recurrence defined as a palpable, reducible lump in the treated groin, with or without symptoms. The time duration for assessment is as early as 6 months and then after 1 year from surgery. Any bulge in the groin on the operated side is considered as recurrence.

Patient is asked to maintain a diary of his health status and particularly related to pain, infection, ability to perform activities with ease or discomfort and any suspected recurrence. he is encouraged to discuss without delay in case of any difficulties noticed as above.

Pain Scoring system

The measurement of pain in the post operative period was assessed using **Visual Analogue Pain Scale. (VAS)** This was selected as it provided a simple, efficient and minimally invasive pain intensity measurement that has been widely used in clinical and research settings in the past for measuring post operative pain.

Sample Visual Analogue scale for assessing pain



The VAS consists of 10 horizontal or vertical lines with "no pain" on one side and "worst pain ever" on the other side. The patient asked to look at the picture and rate his pain intensity. Pain was assessed by measuring duration of analgesic use and subjectively using a VAS till the time patient was in the hospital and on the first follow up visit postoperatively. The pain score was marked at 6, 24, 48, 72 hours and 7 days post operatively. The scores less than 4 is taken as no pain. Score between 4-6 was considered painful but tolerable and was given oral analgesics. Score more than 6 score was considered severe and patient was given parenteral analgesics. Inj. Diclofenac sodium and Inj Tramadol were given as parenteral analgesics given when the pain scores were more than 6. When the pain was between 4 and 6 oral Tab. Diclofenac 50 mg was given. No drugs were given for scores less than 4. The median number of doses of each drug given to each patient was calculated and observed.

OBSERVATIONS AND INFERENCE

OBSERVATIONS & INFERENCE

Age Incidence:

Age incidence			
Sl No	**Age in years**	**Total out of 50**	**%**
2	20-29	4	8
3	30-39	7	14
4	40-49	12	24
5	50-59	16	32
6	60-69	9	18
7	More than 70	2	4

The inguinal hernias are found to be more between 40- 69 years with maximum people admitted between 50- 59 years.

Sex Incidence:

The study was restricted to men only to rule out variations in anatomy which can interfere with analysis of operative and post operative parameters and results without gender difference.

Sex incidence			
Sl No	**Sex**	**Numbers**	**%**
1	Male	50	100
2	Female	0	0

Presenting complaints:

Presenting symptoms			
Sl No	**Symptoms**	**Number of patients**	**%**
1	Groin swelling	45	90
2	Discomfort on exertion	25	50
3	Pain over the swelling	15	30
4	Abdominal pain	2	4
5	Irreducibility	2	4
6	Asymptomatic and presented for other reasons	5	10
7	Obstructive symptoms	0	0

Majority of the patients presented with groin swelling with discomfort on exertion and dull ache or dragging sensation during the course of the day. Pain was the presenting complaint for about 30% of patients. Two patients presented with abdominal pain and irreducibility but without evidence of obstruction. Interesting to notice that 5 patients came for unrelated complaints and found to have inguinal hernia.

Side of Hernia

Sl No	**Type of procedure**	**Numbers**	**%**
1	Right side	30	60
2	Left side	17	34
3	Bilateral	3	6

In our study Right Inguinal hernia was more with tree patients having both left and right hernias.

Type of procedure for Inguinal hernia repair:

Sl No	Type of procedure	Numbers	%
1	Lichtenstein's open meshplasty	25	0.5
2	Minimal invasive Laparoscopic technique	25	0.5

50%of patients underwent Lichtenstein's tension free Mesh repair and another 50 % were operated by Minimally Invasive Laparoscopic method (TAPP). No patients needed conversion open hernioplasty for any reasons.

Duration of surgery: comparison in minutes

Sl No	Type of procedure	Minimum	Maximum	Mean	Mann-Whitney U value.	P Value
1	Lichtenstein's open meshplasty	60	120	91 mts	625	<0.00001
2	Minimal invasive Laparoscopic technique	130	180	157 mts	0	<0.00001

The Value of U is 0. The distribution is apparently normal.

The average duration of open hernioplasty was 91 mts with minimum time taken was 60 mts to maximum time taken upto 120 mts. Whereas the average duration of the minimally invasive Laparoscopic technique was 157 mts with minimum time taken being 130 mts and maximum time 180 mts.

The *Z*-Score is -6.05369. The *p*-value is < .00001. **The result is significant at *p* < .05.**

The duration of surgery was more with Laparoscopic approach which was significant statistically.

The average length of stay in Hospital (ALOS) in days

Sl No	Type of procedure	Minimum	Maximum	Mean	Mann-Whitney U value.	P Value
1	Lichtenstein's open meshplasty	3	7	3.48	209	<0.0455
2	Minimal invasive Laparoscopic technique	2	3	2.88	416	<0.0455

The Value of U is 219. The distribution is apparently normal.

The *Z*-Score is 1.99848. The *p*-value is < .00001. **The result is significant at *p* < .05.**

The average length of stay for Lap patients were lesser than Open hernia repair which was statistically significant.

Intra operative complications

Sl No	Parameters	Open	%	Lap	%
1	Bleeding- procedural	5	20.00	8	32.00
2	Injury to blood vessels	0		0	
3	Injury to Nerves	0		0	
4	Injury to Urinary Bladder	0		0	
5	Injury to Bowel	0		0	
6	Injury to solid abdominal Organs	0		0	

The *U*-value is 17.5. The critical value of *U* at $p < .05$ is 5. **Therefore, the result is *not* significant at $p < .05$.**

There were no major intra operative complications observed other than routine bleeding during dissection and in comparison statistically there were no significant difference.

Comparison of post operative pain and analgesic use.

Statistically as below for POD 1,2,3,7 and followed up at 8 weeks.

POD-1

Sl No	Type of procedure	Minimum	Maximum	Mean	Mann-Whitney U value.	P Value
1	Lichtenstein's open meshplasty	5	7	6.44	220	0.07346
2	Minimal invasive Laparoscopic technique	5	7	6	405	Not significant

The *Z*-Score is 1.78506. The *p*-value is .07346. **The result is *not* significant at $p < .05$**.

POD-2

Sl No	Type of procedure	Minimum	Maximum	Mean	Mann-Whitney U value.	P Value
1	Lichtenstein's open meshplasty	4	6	5.08	22	<0.00001
2	Minimal invasive Laparoscopic technique	3	4	3.88	603	Significant

The *Z*-Score is 5.35519. The *p*-value is < .00001. **The result is significant at $p < .05$**.

POD-3

Sl No	Type of procedure	Minimum	Maximum	Mean	Mann-Whitney U value.	P Value
1	Lichtenstein's open meshplasty	3	5	3.92	36	<0.00001
2	Minimal invasive Laparoscopic technique	1	3	2.68	589	Significant

The *Z*-Score is 5.35519. The *p*-value is < .00001. The result is significant at $p < .05$.

POD- 7

Sl No	Type of procedure	Minimum	Maximum	Mean	Mann-Whitney U value.	P Value
1	Lichtenstein's open meshplasty	3	4	3.36	128	0.00036
2	Minimal invasive Laparoscopic technique	1	3	2.56	497	Significant

The *Z*-Score is 3.57012. The *p*-value is .00036. The result is significant at $p < .05$.

At 8 weeks

Sl No	Type of procedure	Minimum	Maximum	Mean	Mann-Whitney U value.	P Value
1	Lichtenstein's open meshplasty	0	2	1.04	302	0.8493
2	Minimal invasive Laparoscopic technique	0	2	1	323	Not Significant

The *Z*-Score is 0.19403. The *p*-value is .8493. The result is *not* significant at $p < .05$.

At 6 weeks there was no significant pain difference between 2 groups.

- There were no major difference in pain for patients in both groups on 1st POD.
- However On Post-Op day 2 & 3, the patients who underwent laparoscopic hernioplasty had less pain as compared to those undergoing open hernioplasty.
- Mean pain score values in the laparoscopic and open groups were 5.0 vs 3.88 and 3.93 vs 2.68 respectively on POD 2 and 3. which was statistically significant.
- On comparison of pain scores at 7+/- 2 days the pain was more for open cases which was with average scores being 3.36 vs 2.56 respectively for open and lap which was significant.
- However on follow up at 8+/- 1 weeks and 6 months there was difference in pain scores which was not statistically significant.

Consequently patient who underwent open hernioplasty needed more analgesics in the post operative period comparatively during the first three post operative days.

Post operative complications

Complications									
Sl No	**Parameters**	**Open**					**Lap**		
		<3 days	**7 days**	**8 weeks**	**6 months**		**<3 days**	**7 days**	**8 weeks**	**6 months**
1	Urinary retention	5	0	0	0		0	0	0	0
2	Wound Soakage/ Minor Hematoma	5	0	0	0		4	0	0	0
3	Major Bleeding	0	0	0	0		0	0	0	0
4	Pain/tenderness	25	10	0	0		15	2	0	0
5	Local swelling/ induration	15	6	0	0		8	2	0	0
6	Seroma	9	6	1	0		6	3	2	0
7	Secretion from wound	0	2	0	0		0	0	0	0
8	Infection, superficial	1	5	0	0		5	0	0	0
9	Infection, deep	0	1	0	0		0	0	2	0
10	Port herniation	0	0	0	0		0	0	0	0
11	Non specific fever	3	2	0	0		2	0	0	0
12	Venous thrombo embolism	0	0	0	0		0	0	0	0
13	Respiratory tract infections	1	0	0	0		3	0	0	0
14	Mortality	0	0	0	0		0	0	0	0
	Total	**64**	**32**	**1**	**0**		**43**	**7**	**4**	**0**
	Average	**2.56**	**1.28**	**0.04**	**0**		**1.72**	**0.28**	**0.16**	**0**

Post operative complications were assessed during first 72 hours, after 7 days, 8 weeks and at 6 months. Statistically as below.

The Z-Score is 0.64103. The p-value is .52218. **The result is not significant at p < .05.**

The *Z*-Score is 1.81493. The *p*-value is .0703. **The result is *not* significant at *p* < .05**

The *Z*-Score is -0.39056. The *p*-value is .69654. **The result is *not* significant at *p* < .05**.

- Post operatively 5 open hernioplasty patients complained transient urinary retention which was managed conservatively and needed no intervention.
- All lap cases were catheterized preoperatively which was removed on POD-1
- The major complications post operatively within 3 days were pain and tenderness in both groups with patients who underwent open hernioplasty reported more.
- Seroma formation was noticed in 9 and 6 patients in open and lap group respectively. Of which two lap patients suffered deep infections which needed radiological investigations but were managed conservatively without any intervention.
- Lap patients complained of sore throat and two needed drug treatment for upper respiratory tract infection post operatively for 7 days.
- No hernia recurrence noticed between two groups after 6 months and 1 year observations for majority of patients. Hernia recurrence is zero at 6 months follow up for both groups. However 4 open hernioplasty and 7 lap hernioplasty patients have not come for annual follow up.

In summary, in comparison of post operatively complications among both the groups , there was no statistical significance. Most of them were grade II complications managed conservatively and with medications. No major surgical, radiological or endoscopic intervention were required for these patients for complication management. No major complications or deaths noticed.

Comparison resumption of normal activity (in days)

Sl No	Type of procedure	Minimum	Maximum	Mean	Mann-Whitney U value.	P Value
1	Lichtenstein's open meshplasty	1	2.5	1.32 days	254	<0.25848
2	Minimal invasive Laparoscopic technique	1	2	1.16 days	371	<0.25848

The *Z*-Score is 1.12537. The *p*-value is .25848. **The result is *not* significant at $p < .05$.**

- On comparison of resumption of daily activities showed no major difference between two groups with average time being 1.32 days in open vs 1.16 days in lap group.
- Statistically there was no significant difference observed as shown above.
- This was a deviation from our expectation that lap patients will recover back to normal activity faster than the open group.

Comparison of resumption of work and productive life (in days)

Sl No	Type of procedure	Minimum	Maximum	Mean	Mann-Whitney U value.	P Value
1	Lichtenstein's open meshplasty	15	30	20.08days	6	<0.00001
2	Minimal invasive Laparoscopic technique	8	15	10.80 days	619	<0.00001

The *Z*-Score is 5.93727. The *p*-value is < .00001. **The result is significant at $p < .05$**

- The patients who had undergone laparoscopic inguinal hernioplasty returned to work earlier with mean of 10.80 days as compared to 20 days in patients who had undergone open inguinal hernioplasty and difference between two is statistically significant as shown above.
- The lap group returned back to work and became productive faster compared to open group.

ANALYSIS AND CONCLUSIONS

ANALYSIS AND CONCLUSION

Analysis of the study.

The statistical method adopted is the Mann Whitney U test for comparing the treatment variables for two independent sets of data.

- It was observed in this study that the **mean operating time** for patient undergoing laparoscopic hernioplasty was significantly more as compared to that of patients undergoing open inguinal hernioplasty. Several studies has shown that lap hernioplasty incurred more operative time as compared to open hernioplasty.
- There was significant **pain** difference between patients undergoing laparoscopic hernioplasty as compared to open hernioplasty with lap group having less pain from 2nd POD onwards till first week post surgery with consequent lesser analgesic requirement post operatively. This was similar to many studies which compared these two techniques. However after 8 weeks of follow up there was no major difference in pain between the groups.
- The **average length of stay (ALOS)in hospital** for open hernioplasty group was slightly higher than the lap group which was significant statistically and consistent with other studies.
- There was no significant differences in **intra-op and post op complications** noticed. Seromas was higher in laparoscopic meshplasty patients than open group even though not significant statistically. However in two patients who underwent laparoscopic hernioplasty, developed deep seated infections which required a radiological investigations like Ultrasound and CT but without any intervention. It is assumed that persistent seroma was responsible for the same.

- The **time** required **for return to daily activities** for patients undergoing laparoscopic inguinal hernioplasty was significantly lower as compared to that of open inguinal hernioplasty as with other studies.
- Similarly **time** required to **resume normal productive life and return to work** was also faster with laparoscopic group as compared to open hernioplasty group which was statistically significant similar to other studies.
- The 6 months and 12 months follow up of patients did not show any recurrence.

Parameter	**Open Inguinal Hernioplasty (Lichtenstein's repair)**	**Laparoscopic hernioplasty (TAPP)**
Duration of Surgery	Less	More
Intra-op complications	Less	More chances for injury to major blood vessels, nerves and solid organs.
Anesthetic complications	Less (can be done in Spinal or Regional Anesthesia)	More chances due to General Anesthesia.
Post op Pain and medication requirement	Pain comparatively more with more medications	Lesser than open technique
Post op immediate complications like hematoma, seroma etc	Comparatively More	Lesser immediate post op complications in trained hands
Return to normal activities	Later with Open technique	Faster recovery and return to normal activities

Average length of stay in hospital	More	Less
Return of wok life	Took more time to return to normal work routine.	Faster to work and return to normal work routine
Chronic pain	More likely	Less likely
Learning curve	Easy to learn and reproduce with comparable results	Steep learning curve and will take a long time for good results
Cost factor	Relatively cheap and affordable	Expensive and requires technologically intensive equipments and devices.

CONCLUSION

The laparoscopic hernioplasty offers advantages in terms of lesser postoperative pain and analgesic requirements as well as a significantly early return to work. The incidence of chronic debilitating pain is also significantly lower than with open mesh repair in the first 3 months post operatively. It offers the advantage of examining the opposite side for the presence of a small hernia sac even when operating for a clinically present unilateral inguinal hernia. In cases of recurrent hernia, following previous open mesh repair, the laparoscopic approach allows access to the hernial site without going through scarred tissues or mesh.

The minimal invasive hernioplasty is an advanced laparoscopic procedure which has a long learning curve with duration of surgery significantly higher than open hernioplasty. In the hands of inexperienced and

trainee surgeons there can be higher complication and recurrence rates. The initial investment and the running expenses for maintenance is high.

In spite of some clear advantages compared with open meshplasty, the routine use of this technique may take time to be adopted in high through put centers with heavy work load. It's use will be tailor made to those cases where Laparoscopic approach is more beneficial like recurrent and bilateral hernias without co-morbidities. Also as a teaching institution Post graduates needs to be familiar with latest in treatment modalities for a common condition like groin hernia. Laparoscopic approach with its variation of anatomical landmarks compared to open approach needs to be demonstrated to students. Hence laparoscopic hernioplasty may continued to be use for appropriate cases.

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ANNEXURE

ANNEXURE I: PROFORMA

- ✓ **Patient's Name**
- ✓ **Age/Sex**
- ✓ **IP Number**
- ✓ **Occupation**
- ✓ **Address**

Presenting Complaints:

- Swelling- onset, duration, Aggravating and relieving factors
- Spontaneously reducible or irreducible, able to reduce himself.
- Pain over the swelling- nature, duration, aggravating and relieving factors
- H/o suggestive of obstruction- irreducibility with severe pain, with or without abdomen distention, vomiting, fever.
- Bowel and bladder status
- History related to predisposing factors:
    - Nature of work and activity
    - H/o suggesting of COPD
    - H/o suggestive of Bladder out flow obstruction
    - H/o suggestive of strain while passing urine, habitual constipation
    - Any previous lower abdominal surgeries
    - H/o ascites or any other condition increasing intra abdominal pressure
    - Smoking
- Previous treatment history for similar illness in case of recurrence
- Any co morbidities with treatment history.

Physical Examination:

General examination:

- Height/weight/build and nourishment
- Vital signs (temperature/pulse/BP/Resiration)

- Pallor, Icterus, Cyanosis, Clubbing, Lympadenopathy and Edema

Systemic examination:

- Cardiovascular system/Respiratory system
- Per abdomen examination including Per rectal examination

Local Examination: (In standing and lying down position)

- Site/ size/shape/Extend/surface/margin
- Expansile cough impulse
- Direct/indirect/bilateral/femoral
- Reducible/irreducible/obstructed
- Contents
- Genitalia

Investigations:

- Complete blood count/Renal/Liver function test
- Blood grouing/typing/BT/CT
- Vital markers
- ECG
- X ray Chest PA view
- USG Inguino-scrotal region, Abdomen/pelvis/ prostate size and Post void residual urine.

Required assessments and fitness for surgery.

Annexure II : Post-Operative complications assessment

Grade I :

Deviation from ideal postoperative course without need of pharmacological treatment, surgical, endoscopic, radiological intervention.

Allowed therapeutic regimens are drugs such as antiemetic, antipyretic. analgesic diuretics, physiotherapy. This grade also includes wound infections open at bedside.

Grade II:

Requiring pharmacological treatment within drugs other than such allowed for grade I complication. Blood transfusion and total parenteral nutrition are also included.

Grade III:

Requiring surgical endoscopic or radiological intervention.

- IIIa Intervention not under general anesthesia
- IIIb Intervention under general anesthesia.

Grade IV:

Life threatening complication requiring ICU management

- IVa Single organ dysfunction
- IVb Multiple organ dysfunction.

Grade V:

Death of patient

Reference: Classification of Surgical Complications A New Proposal With Evaluation in a Cohort of 6336 Patients and Results of a Survey Daniel Dindo, MD, Nicolas Demartines, MD, and Pierre-Alain Clavien, MD, PhD, FRCS, FACS Ann Surg. 2004 August;

ANNEXURE III : MASTER DATA

Patient Demographics

Sl No:	Name	Age/Sex	Diagnosis	Type of Intervention
1	Sundar	60/M	Left Inguinal hernia	Lichtenstein's Mesh Repair
2	Mustafa	26/M	Right Inguinal hernia	TAPP*
3	Kalaivanan	65/M	Right Inguinal hernia	Lichtenstein's Mesh Repair
4	Yesudasan	34/M	Right Inguinal hernia	TAPP
5	Pichaimuthu	58/M	Right Inguinal hernia	Lichtenstein's Mesh Repair
6	Hariprakash	50/M	Right Inguinal hernia	TAPP
7	Gurumurthy	51/M	Right Inguinal hernia	Lichtenstein's Mesh Repair
8	Munuswamy	44/M	Right Inguinal hernia	TAPP
9	Veeran	58/M	Left Inguinal hernia	Lichtenstein's Mesh Repair
10	Rajendran	55/M	Left Inguinal hernia	Lichtenstein's Mesh Repair
11	Ravi	28/M	Right Inguinal hernia	TAPP
12	Shanker	39/M	Right Inguinal hernia	TAPP
13	Muthu	60/M	Right Inguinal hernia	Lichtenstein's Mesh Repair
14	Mohammed Ghouse	48/M	Right Inguinal Hernia	Lichtenstein's Mesh Repair
15	Stephen	53/M	Right Inguinal hernia	TAPP
16	Subramani	40/M	Right Inguinal hernia	TAPP
17	Murali	25/M	Right Inguinal hernia	TAPP
18	Nagarajan	45/M	Left Inguinal hernia	TAPP

19	Elumalai	56/M	Bilateral Inguinal Hernia	Lichtenstein's Mesh Repair
20	Kothandam	37/M	Right Inguinal hernia	TAPP
21	Thangavel	66/M	Left Inguinal hernia	Lichtenstein's Mesh Repair
22	Arumugam	63/M	Left Inguinal hernia	Lichtenstein's Mesh Repair
23	Devadas	51/M	Left Inguinal hernia	TAPP
24	Samuel Philip	33/M	Right Inguinal hernia	Lichtenstein's Mesh Repair
25	Velusamy	54/M	Right Inguinal hernia	Lichtenstein's Mesh Repair
26	Shankaran	54/M	Right Inguinal hernia	TAPP
27	Viramani	57/M	Left Inguinal hernia	Lichtenstein's Mesh Repair
28	Ranganathan	71/M	Right Inguinal hernia	Lichtenstein's Mesh Repair
29	Manickam	43/M	Right Inguinal hernia	TAPP
30	Rajavel	49/M	Right Inguinal hernia	TAPP
31	Lingapppa	65/M	Right Inguinal hernia	Lichtenstein's Mesh Repair
32	Rajendran	44/M	Right Inguinal hernia	TAPP
33	Raju	46/M	Right Inguinal hernia	TAPP
34	Sridhar	42/M	Left Inguinal hernia	TAPP
35	Kumar	34/M	Left Inguinal hernia	TAPP
36	Muthuraman	70/M	Left Inguinal hernia	Lichtenstein's Mesh Repair
37	Vijayakumar	37/M	Left Inguinal hernia	TAPP
38	Sundaresan	59/M	Bilateral Inguinal Hernia	Lichtenstein's Mesh Repair

39	Kondayyah	67/M	Bilateral Inguinal Hernia	Lichtenstein's Mesh Repair
40	Devasahayam	55/M	Right Inguinal hernia	Lichtenstein's Mesh Repair
41	Marimuthu	59/M	Left Inguinal hernia	Lichtenstein's Mesh Repair
42	Palani	64/M	Right Inguinal hernia	Lichtenstein's Mesh Repair
43	Pradeep	27/M	Right Inguinal hernia	TAPP
44	Kuppan	58/M	Right Inguinal hernia	Lichtenstein's Mesh Repair
45	Varadarajan	50/M	Left Inguinal hernia	Lichtenstein's Mesh Repair
46	Babu Victor	38/M	Left Inguinal hernia	TAPP
47	Govindan	45/M	Right Inguinal hernia	TAPP
48	Manimaran	40/M	Left Inguinal hernia	TAPP
49	Vetrivel	62/M	Left Inguinal hernia	Lichtenstein's Mesh Repair
50	Iyyappan	44/M	Right Inguinal hernia	TAPP

Duration of Surgery in minutes:

Sl.No	Lichtenstein's open meshplasty	Minimal invasive Laparoscopic technique
1	60	135
2	90	130
3	75	180
4	80	150
5	85	170

6	95	135
7	100	150
8	85	150
9	90	145
10	95	170
11	85	160
12	100	170
13	110	145
14	95	160
15	90	155
16	85	140
17	110	160
18	90	180
19	95	150
20	75	180
21	85	150
22	110	170
23	90	165
24	120	155
25	85	180
Total time	**2280**	**3935**
Average time	**91.2**	**157.4**

Comparison of post operative pain and analgesic use

Pain during hospital stay (VAS based)													
	Open							Lap					
Sl.No	Day 1	day 2	day 3	7 days	8 weeks	6 months		day 1	day 2	day 3	7 days	8 weeks	6 months
1	7	5	4	3	3	0		7	4	3	3	1	0
2	6	5	3	3	3	1		6	4	3	2	1	0
3	7	5	4	4	3	0		5	4	3	3	1	0
4	6	6	4	3	3	1		6	4	3	3	1	1
5	5	5	4	4	2	0		6	4	2	3	0	0
6	7	5	4	3	3	1		7	4	3	2	2	0
7	6	5	4	3	3	1		6	4	3	3	2	0
8	6	6	3	3	2	1		6	4	3	2	1	0
9	6	5	4	3	3	1		5	4	3	1	1	0
10	7	4	4	4	3	1		6	4	3	3	1	1
11	6	5	4	3	2	1		6	3	3	1	2	0
12	6	5	4	3	3	1		6	4	2	3	1	0
13	7	5	4	3	3	1		5	4	3	2	0	0
14	6	5	5	4	3	1		6	4	2	3	2	1
15	8	4	4	3	3	0		6	3	3	3	1	0
16	7	5	4	3	2	1		7	4	3	3	1	0
17	6	5	3	4	3	1		6	3	2	2	0	0
18	6	6	4	3	2	0		6	4	3	3	1	1
19	5	5	4	3	3	1		6	4	3	3	1	0
20	8	6	4	3	3	0		6	4	3	3	1	0
21	6	5	4	3	3	1		6	4	1	2	1	0
22	7	5	5	4	1	0		6	4	2	3	0	1
23	6	5	4	4	3	1		6	4	2	2	1	0
24	8	5	3	4	3	0		6	4	3	3	1	0
25	6	5	4	4	3	1		6	4	3	3	1	0
Total score	**161**	**127**	**98**	**84**	**68**	**17**		**150**	**97**	**67**	**64**	**25**	**5**
Average	**6.44**	**5.08**	**3.92**	**3.36**	**2.72**	**0.68**		**6**	**3.88**	**2.68**	**2.56**	**1**	**0.2**

Comparison of return to normal activities and productive life after surgery

Time to normal activity in days				Time to resumption of work		
Sl No	**Open**	**Lap**		Sl No	Open	Lap
1	1	1		1	15	9
2	1.5	1		2	20	10
3	1	1		3	18	12
4	2	1		4	17	10
5	1	1		5	20	15
6	1	1		6	30	12
7	1.5	2		7	15	9
8	1	1		8	17	8
9	2.5	1		9	25	10
10	1	1		10	20	10
11	1	1		11	18	8
12	1	1		12	20	8
13	1	2		13	18	10
14	2.5	1		14	25	11
15	1	1		15	15	15
16	1	1		16	17	10
17	1.5	1		17	20	10
18	1	1		18	18	10
19	2	1		19	26	11
20	1	1		20	30	10
21	1.5	1		21	25	12
22	1	2		22	20	10
23	1	1		23	21	14
24	1	2		24	15	11
25	2	1		25	17	15
Total	**33**	**29**		**Total**	**502**	**270**
Mean	**1.32**	**1.16**		**Mean**	**20.08**	**10.8**